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ANNUAL REPORT
RANGE REVEGETATION INVESTIGATIONS

FORAGE & RANGE SECTION
FIELD CROPS RESEARCH BRANCH
AGRICULTURAL RESEARCH SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE

in cooperation with

NEVADA AGRICULTURAL EXPERIMENT STATION
and
INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION

by

A. T. BLEAK, RANGE CONSERVATIONIST

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Copy Number 4

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I. INTRODUCTION -- FC-c9: PASTURE AND RANGE INVESTIGATIONS, UNDER ARID, SEMI-ARID, AND SUB-HUMID CONDITIONS

Artificial revegetation investigations were first activated in Nevada in 1936 by the Intermountain Forest and Range Experiment Station. Early work was centered at Ruby Substation (near Wells, Nevada) and at Santa Rosa Substation (near Paradise Valley, Nevada). These substations were situated to foster the study of reseeding problems in three vegetative types: depleted sagebrush, burned sagebrush and mountain brush.

From June 1951 to September 1952 artificial revegetation research activities in Nevada were carried on at a maintenance level. In the fall of 1952, work was reactivated at Reno, Nevada. Research in sagebrush and other vegetative types was continued but major emphasis has been on soil stabilization and increased forage on watersheds and ranges at higher elevations along the east face of the Sierra-Nevada range. Close cooperation with the Nevada Agricultural Experiment Station, other research agencies, action agencies, and private groups was maintained.

The Nevada position has been without assigned personnel from July 1, 1956 to the present. However, field data was taken on all major studies in Nevada during the summer and fall of 1956. This material is included in this report. The position at Ephraim, Utah

was without assigned personnel from March to July 1, 1956. Orientation and reactivation of established work and establishment of new work projects accounted for the balance of the 1956 field season. The work in central Utah is also included in this report.

Foreign Visitors and Technical Assistance

Approximately 14 hours were spent with foreign visitors. These were as follows:

J. N. Pandey	India
Falah Ghariabeh	Jordan
Fernando Barrientos	Spain
Alfonso Villuandos	Spain

In addition 54 hours were spent giving technical assistance or reviewing findings with extension workers, action agencies or private groups.

Acknowledgements

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Bureau of Land Management

Forest Service, Region 4

Intermountain Forest and Range Experiment Station

Soil Conservation Service

University of Nevada

Utah State Agricultural College

Appreciation is expressed to all personnel who assisted in laboratory or field work, reviewed study plans or manuscripts, and for their many helpful suggestions. Special thanks are due the University of Nevada and the Intermountain Forest and Range Experiment Station for providing office space and other services.

II. FC-c9-2: EVALUATION OF GRASSES AND LEGUMES ALONE AND IN COMBINATION FOR ADAPTATION TO RANGE CONDITIONS

Approximately 65 million acres or 93 percent of the state of Nevada is rangeland. Precipitation is generally too low for dryland farming and irrigation farming is limited by water available from watersheds. Although the rangelands of Nevada are thought of as grazing lands for cattle, sheep and other domestic livestock, they have other uses and yield other benefits. Many are important as watersheds, some for timber or for recreation and all in some degree as habitat for wildlife.

Mining has been actively carried on in Nevada since the gold-rush days of 1849. Farming and ranching were slower to develop. By 1860 there were less than 100 farms or ranches. However, this number increased to over 1,000 in the next 10 years and cattle and sheep numbers increased rapidly. By 1900, ranges were fully grazed and some writers claim many of the better forage types were depleted. On high summer ranges logging together with grazing reduced the plant cover. Channels were cut in many of the meadows; gullies formed on skid roads and soil movement on slopes increased. On foothill ranges grazing reduced the perennial grass cover and permitted big sagebrush, juniper, and cheatgrass to increase. On winter ranges heavy grazing reduced the black sagebrush, winterfat, and palatable native grasses, permitting the increase of shadscale, rabbitbrush, Russian thistle, cheatgrass, and halogeton. Surveys made in 1932 indicated many ranges were producing only 40 to 50 percent of capacity.

Suitable species are needed to maintain soil stability and prevent destructive floods. Species should be used which are adapted to the environment. Species may be well adapted to a particular climate or soil but still fail because of some other environmental factors. This has led to an effort to distinguish between those inherent climatic and edaphic factors which must be met by species selection as opposed to factors such as grazing use, insects, rodents, and disease.

II-A. ARTIFICIAL REVEGETATION ON THE EASTERN SLOPE OF THE SIERRA-NEVADA RANGE

Extensive timber cutting began on the east face of the Sierra-Nevada range in 1850 with the demand for lumber by the mining industry. Cutover lands have frequently burned over and forest fires have destroyed large tracts of timber. These lands have also been heavily grazed by livestock and game. As a result, total plant cover has been reduced, shrubby species have invaded and a large portion of the topsoil and organic matter has been lost through erosion.

Fall, winter, and spring floods have been a serious problem on the east slope of the Sierra-Nevada range and the Christmas week flood in 1955 was a grim reminder of the importance of these floods. The first of 10 destructive floods recorded occurred in December of 1861. All of these floods except one in May of 1890, apparently resulting from melting snow, have occurred following heavy rainstorms,

at least at lower elevations. Usually precipitation occurring from late fall and prior to the middle of March will fall as snow at higher elevations and when in the form of rain it will be absorbed by the snow blanket. However, rain falling on shallower low-level snow may melt the snow, thus increasing the runoff.

Storms producing these floods usually are extensive and may continue for several days. Destructive summer floods also occur. These floods are usually localized flash floods, such as the one which occurred on Galena Creek in July of 1952.

If land misuse is responsible or partially responsible for the floods, intensive work in artificial revegetation, management, and on-site engineering may be needed to rehabilitate the watersheds and rangelands. These floods have resulted in federal expense in the form of flood relief. Transcontinental traffic was stopped and serious damage to property resulted from the 1950 and 1955 floods. Several federal reclamation projects are involved. It has been demonstrated that the plant cover and soil mantle exerts a high degree of control on the reception and disposition of precipitation, resulting in relatively low normal rates of erosion, in normally moderate peak stream discharge and in normally small sediment loads.

Range users are now faced with the very difficult problem of stopping further depletion and of returning depleted ranges to good production. Additional forage is urgently needed for livestock and existing game animals if the livestock men are going to maintain their present herds and the industry.

1. Galena Creek

This area, located near the head of Galena Creek at an elevation of 9,700 feet, has been severely depleted by heavy sheep use. A high intensity summer storm on this area in July of 1952 resulted in severe damage to the Galena Creek campground and to several ranches in the valley below. A similar flood from the lower portion of this area in July of 1956 resulted in loss of human life and considerable damage. This area is typical of many of the watersheds on the east face of the Sierra-Nevada range.

This study was established in conjunction with a watershed rehabilitation project being conducted by the Toiyabe National Forest on the Carson Ranger District. Species plots were established near the watershed rehabilitation project on September 19, 1953. A similar planting was made October 11, 1954 and selected species were planted on vacant plots within the 1953 planting on October 13, 1955. All grasses, forbs, and shrubs included in this study were planted in 3 row plots, each 5 feet wide by 10 feet long. Snow usually stays on this area until midsummer. Plots were still covered with snow on June 15 in 1954 and 1955, but the area was free of snow on July 5 in 1954 and July 1 in 1955. In 1956, most of the plot area was still covered with snow on July 15, but a large portion of the rehabilitation project area was free of snow on this date.

Most of the species planted produced good seedling stands in 1954, 1955, and 1956 (table 1). Seedling plants usually made little growth and were low in vigor. There was some mortality during the winter of 1954-1955 but some of the wheatgrasses, several fescues, native Stipa, native Sitanion, and several brome grasses still produced fair to good stands in their second year. Seedling plants, 2-year old plants, and 3-year old plants were spindly, and yields from the best species were less than 135 pounds of herbage per acre. Orchardgrass, red fescue, Bromus tomentellus and intermediate wheatgrass were among the best introduced species. On these areas, where soil fertility appears to be a problem, native Stipa, Sitanion, mountain brome, and Hesperochloa were among the best species. It seems that native species growing on deficient soils are best able to get along with the nutrients in short supply.

Phosphates were applied, at a rate of 200 pounds of P_2O_5 per acre, to one-half (one block) of the area seeded in the fall of 1953. This treatment did not appear to have any measurable beneficial effects as judged by plant growth on the plot areas but a response to P_2O_5 when applied with nitrogen was observed in the pot fertility tests discussed under Section III-A of this report. In the fall of 1955 the area treated with P_2O_5 in the fall of 1954 was treated with slaked lime at a rate of 1½ tons per acre. The plants on this area which received P_2O_5 in 1954 and lime in 1955 were slightly taller, slightly different in color and more vigorous than

Table 1 . Relative rating, number of plants per linear foot of row, average height and estimated air-dry herbage production at Galena Creek plot area.

Plot	Species and Lot	Age[1]	Relative Rating[2] 1954	1955	1956	Number Plants[3] 1956	Height (ins.) 1956	Yield P/A 1956
	Grasses							
311	Agropyron amurense 1	3	10	8	8	2.2	4	50
620	(A. intermedium)	3	10	8	10	2.8	5	60
D4		2	-	10	9	3.0	2	20
H2		2	-	10	6	2.8	2	20
303	" cristatum 28	3	10	1	0	0	-	-
619		3	10	2	0	0	-	-
A5		2	-	10	0	0	-	-
I5		2	-	4	0	0	-	-
404	" elongatum 9	2	10	6	2	0.3	1	T
518		2	10	4	1	0.2	1	T
505	" intermedium	3	10	6	4	1.1	2	20
419	"	3	10	8	9	2.5	2	50
C4		2	-	10	6	1.7	2	30
G2		2	-	10	3	0.9	2	10
607	" intermedium 52	1	-	-	10	6.1	2	10
313		1	-	-	10	5.7	2	10
407	" intermedium 32009	1	-	-	10	7.0	2	10
314		1	-	-	10	5.5	2	10
406	" intermedium 32058	1	-	-	10	6.7	2	10
312		1	-	-	10	7.1	2	10
111	" repens 14	3	10	7	3	1.0	2	20
421		3	10	8	8	3.0	2	50
C3		2	-	10	1	0.3	2	T
G1		2	-	8	2	0.4	2	T
507		1	-	-	10	5.5	1	T
414		1	-	-	10	6.0	1	T
405	" smithi 43	3	10	6	2	0.4	2	T
519		3	10	4	2	0.4	2	T
B4		2	-	6	0	0	-	-
G5		2	-	4	1	0.1	1	T
211	" spicatum 50	3	4	0	0	0	-	-
121		3	1	2	0	0	-	-

Plot	Species and Lot	Age[1]	Relative Rating[2] 1954	1955	1956	Number Plants[3] 1956	Height (ins.) 1956	Yield P/a 1956
212	Agropyron subsecundum 44	3	10	10	7	2.2	2	30
622		3	10	8	8	2.7	2	30
304	" trachycaulum 48	3	10	8	6	2.0	2	30
517		3	10	8	7	2.1	2	40
C7		2		10	10	4.7	2	30
17		2		5	3	0.9	2	10
204	" " 61	3	10	6	7	1.4	3	30
417		3	10	8	9	3.0	5	60
C8		2		10	10	4.0	3	40
I6		2		6	3	1.2	4	10
302	" trichophorum 56	3	10	6	1	0.2	2	T
618		3	10	8	7	1.6	2	10
C1		2		10	3	0.4	2	T
G3		2		10	2	0.3	1	T
402	Alopecurus arundinaceus 1	3	10	5	2	0.4	2	T
616		3	10	6	5	1.5	2	10
B8		2		6	2	0.5	2	T
H6		2		3	2	0.5	2	T
403	" pratensis A	3	10	8	5	1.1	2	30
617		3	10	6	6	1.6	2	40
B7		2		8	2	0.4	2	T
H7		2		3	2	0.3	2	T
605	Arrhenatherum elatius A	3	10	2	2	0.4	2	T
416		3	10	4	3	0.5	2	T
A7		2		6	0	0	-	-
J5		2		2	1	0.1	2	T
606	" elatius 31	3	10	3	3	0.5	2	T
220		3	10	8	5	1.0	3	10
110	Bromus carinatus 78	3	10	8	6	2.1	3	50
420		3	10	8	9	3.5	3	60
F4		2		10	10	4.1	3	60
J1		2		8	7	2.4	3	60
108	" " 94	3	10	10	2	0.3	2	T
122		3	10	8	6	1.3	2	10
F3		2		6	6	1.1	2	10
J2		2		2	2	0.2	2	T
112	" " 102	3	10	8	3	0.5	2	T
120		3	10	5	2	0.4	1	T
F2		2		10	7	1.6	2	T
K1		2		4	2	0.3	2	T

Plot	Species and Lot	Age[1]	Relative Rating[2] 1954	1955	1956	Number Plants[3] 1956	Height (ins.) 1956	Yield P/A 1956
109	Bromus carinatus A	3	10	10	10	5.4	5	70
521		3	10	10	10	5.0	5	80
F1		2		10	10	4.9	4	50
J4		2		8	10	3.5	5	60
305	" " N1	1			10	6.4	2	10
615		1			10	7.1	2	10
210	" erectus 5	3	10	2	3	0.5	1	T
522		3	10	6	6	1.3	2	10
H1		2		5	1	0.2	1	T
J3		2		5	2	0.3	1	T
306		1			10	3.2	1	T
514		1			10	2.6	1	T
317	" inermis A	3	10	5	6	0.9	2	30
604		3	10	6	2	0.3	2	T
E4		2		10	2	0.3	2	T
K4		2		6	6	0.9	2	10
209	" " 47	3	10	2	2	0.3	1	T
320		3	10	2	2	0.3	1	T
E3		2		10	3	0.4	1	T
K2		2		5	2	0.3	1	T
206	" " 24846	1			10	2.5	1	T
515		1			10	3.0	1	T
207	" " 32224	1			10	3.2	1	T
516		1			10	2.4	1	T
208	" " 32259	1			10	3.0	1	T
513		1			10	2.5	1	T
205	" marginatus 32623	1			10	2.6	2	T
614		1			10	2.3	2	T
603	" tomentellus 5	3	10	10	10	4.3	3	60
316		3	10	10	10	5.5	5	70
E2		2		10	10	6.1	4	40
K3		2		10	7	2.0	2	20
504	Dactylis glomerata A	3	10	6	5	1.2	3	30
318		3	10	8	6	1.7	3	20
C6		2		10	10	4.2	4	60
J6		2		6	2	0.5	2	10
511	" " 28	1			10	4.5	1	T
321		1			10	5.0	1	T

Plot	Species and Lot	Age[1]	Relative Rating[2] 1954	1955	1956	Number Plants[3] 1956	Height (ins.) 1956	Yield P/A 1956
510	Elymus condensatus 14	3	10	0	0	0	-	-
115		3	6	0	0	0	-	-
205	" glaucus 29	3	2	0	0	0	-	-
214		3	2	0	0	0	-	-
310	" junceus 38	3	5	0	0	0	-	-
520		3	8	0	0	0	-	-
A6		2		7	0	0	-	-
11		2		4	0	0	-	-
106	" triticoides A	3	8	8	0	0	-	-
116		3	4	5	1	0.2	1	T
D3		2		6	2	0.3	1	T
G4		2		5	1	0.2	1	T
602	" " B	3	10	6	1	0.1	1	T
117		3	3	4	1	0.2	1	T
D2		2		10	2	0.3	1	T
H3		2		7	1	0.2	1	T
107	" " C	3	5	4	4	0.5	2	10
216		3	3	1	1	0.2	2	T
D1	D	2		10	0	0	-	-
H4		2		8	0	0	-	-
608	" " N2	1			10	2.6	1	T
221		1			8	1.5	1	T
105	Festuca elatior arundinacea	3	10	?	0	0	-	-
215		3	10	3	1	0.2	1	T
A3		2		10	0	0	-	-
F8		2		10	3	0.4	1	T
202	" ovina duriuscula A	3	10	3	2	0.3	1	T
219		3	10	5	5	1.5	1	10
A2		2		10	6	1.7	1	10
F7		2		10	2	0.3	1	T
102	" rubra commutata A	3	10	10	10	5.6	2	60
118		3	10	10	10	7.0	1	50
B2		2		10	10	6.7	1	50
G7		2		10	10	7.3	1	60
309		1			10	8.0	1	10
115		1			10	7.8	1	10

Plot	Species and Lot	Age[1]	Relative Rating[2] 1954	1955	1956	Number Plants[3] 1956	Height (ins.) 1956	Yield P/A 1956
104	Festuca rubra - A	3	10	10	10	7.4	1	50
218		3	10	10	10	6.2	1	60
A1		2		10	8	5.0	1	40
G8		2		10	10	6.6	1	50
307		1			10	7.7	1	10
114		1			10	8.1	1	10
103	" " stolonifera A	3	10	10	10	6.1	1	40
119		3	10	8	6	3.3	1	50
B1		2		10	10	6.0	1	50
G6		2		10	10	6.6	2	70
203	Hesperochloa kingi 2	3	8	7	6	1.2	2	20
217		3	10	10	10	3.5	3	50
B3		2		10	10	4.5	3	70
F5		2		10	10	5.6	3	70
113	Melica bulbosa 9	3	10	6	3	0.5	2	10
D5		2		10	2	0.3	1	T
I3		2		3	2	0.2	1	T
308		1			10	4.2	1	T
415		1			10	3.7	1	T
406	Phalaris arundinacea 5	3	4	0	0	0	-	-
313		3	0	0	0	0	-	-
A8		2	0	4	0	0	-	-
H5		2		2	0	0	-	-
503	Phleum pratense A	3	10	4	5	0.9	2	T
418		3	10	4	2	0.3	2	T
306	Poa ampla 41	3	6	0	0	0	-	-
213		3	10	0	0	0	-	-
A4		2		2	0	0	-	-
F6		2		1	0	0	-	-
502	" pratensis A	3	10	2	0	0	-	-
319		3	8	2	0	0	-	-
C2		2		6	0	0	-	-
H1		2		3	0	0	-	-
312	Secale cereale A	3	8	0	0	0	-	-
407	Secale montanum 29	3	8	0	0	0	-	-
321		3	2	0	0	0	-	-

Plot	Species and Lot	Age[1]	Relative Rating[2] 1954	1955	1956	Number Plants[3] 1956	Height (ins.) 1956	Yield P/A 1956
411	Sitanion hystrix A	3	10	10	10	6.2	4/7	70
322		3	10	10	10	5.0	4/6	60
C5		2		10	10	5.6	3	50
I8		2		10	10	6.6	4	60
409		1			10	7.4	2	10
612		1			10	6.8	2	10
508	Stipa columbiana 35	3	10	7	8	2.6	3	40
422		3	10	8	8	3.1	3	50
408		1			10	5.6	2	10
412		1			10	6.3	2	10
607	" lettermani 11	3	3	0	0	0	-	-
221		3	2	1	0	0	-	-
506	" viridula 16	3	10	1	2	0.4	2	T
222		3	10	2	3	0.5	2	T
B5		2		10	3	0.5	2	T
I4		2		4	2	0.4	2	T
310		1			8	2.1	1	T
413		1			8	1.8	1	T
509	Stipa spp. A	3	10	10	10	5.3	4	70
621		3	10	10	10	4.6	4/6	130
B6		2		10	10	6.5	4	70
H8		2		10	10	5.3	3	60
410		1			10	6.2	2	10
512		1			10	5.6	2	10
	Forbs							
307	Astragalus cicer 1A	2	4	1	0	0	-	-
514		2	5	0	0	0	-	-
409	" falcatus 11	3	4	0	0	0	-	-
412		3	7	0	0	0	-	-
507	Helianthella uniflora 3	3	0	0	0	0	-	-
612		3	0	0	0	0	-	-
206	Heracleum lanatum 6	2	0	3	0	0	-	-
614		2	0	1	0	0	-	-
208	Lathyrus sylvestris 5	3	6	1	0	0	-	-
515		3	4	1	0	0	-	-

Plot	Species and Lot	Age[1]	Relative Rating[2] 1954	1955	1956	Number Plants[3] 1956	Height (ins.) 1956	Yield P/A 1956
	Forbs							
609	Lupinus alpestris 8	3-1	5	0	2	0.3	1	T
613		3-1	6	0	4	0.6	1	T
D6		2		2	0	0	-	-
I2		2		2	0	0	-	-
E8	Lupinus spp. N1	1			2	0.3	1	T
J8		1			4	0.5	1	T
601	Medicago falcata 3	3	3	0	0	0	-	-
623		3	4	0	0	0	-	-
207	" sativa 36	3	0	0	0	0	-	-
615		3	2	0	0	0	-	-
E6		2		0	0	0	-	-
J7		2		0	0	0	-	-
408	" " 45	3	3	0	0	0	-	-
414		3	0	0	0	0	-	-
305	Osmorhiza occidentalis 18	3	0	0	0	0	-	-
516		3	0	0	0	0	-	-
309	Trifolium repens 3	3	0	0	0	0	-	-
512		3	2	0	0	0	-	-
308	Valeriana edulis 2	3	2	0	0	0	-	-
513		3	0	0	0	0	-	-
610	Vicia tenuifolia 6	3	5	6	1	0.2	2	T
315		3	7	3	1	0.1	2	T
608	Viguiera multiflora 10	3	0	0	0	0	-	-
314		3	2	0	0	0	-	-
	Shrubs							
611	Cercocarpus ledifolius A	3	3	0	0	0	-	-
114		3	8	0	0	0	-	-
E5		2		1	0	0	-	-
K8		2		0	0	0	-	-
511	Purshia tridentata A	3	0	0	0	0	-	-
415		3	2	0	0	0	-	-
E7		2		1	0	0	-	-
K7		2		0	0	0	-	-

Plot	Species and Lot	Age[1]	Relative Rating[2] 1954	1955	1956	Number Plants[3] 1956	Height (ins.) 1956	Yield P/A 1956
	Shrubs							
D8	Sambucus cerulea 1	2		0	0	0	-	-
K6		2		0	0	0	-	-
611	" microbotrys N1	1			0	0	-	-
520		1			0	0	-	-
D7		2		0	0	0	-	-
K5		2		0	0	0	-	-

1/ Age: 1= plants in seedling stage; 2= plants in second growing season; and 3= plants in third growing season.

2/ Relative ratings are based on summation of ratings for plant number and distribution. 1-2 very poor; 3-4 poor; 5-6 medium; 7-8 good; 9-10 very good.

3/ Number of plants per linear foot of row.

on the untreated area but even these plants were small and spindly. Pot tests on soil from this area showed a good response where lime, nitrogen, and phosphates were all applied together. Additional field tests with nitrogen, phosphates, and heavier rates of lime are warranted.

2. Dog Valley

A species adaptability study was established in Dog Valley, California in the fall of 1951 on an old burn on the Verdi-Dog Valley Summit. The soil on this site is a shallow loose sandy-loam which dries rapidly, has a pH of 5.8, and appears to be low in fertility. Diurnal temperature fluctuations are usually high during the normal growing season. A dense stand of greenleaf manzanita (Arctostaphylos patula) and snowberry ceanothus (Ceanothus velutinus) came in after the fire and now dominates this burn. Because manzanita and ceanothus retard re-establishment of trees and provide competition to desirable forage species, these shrubs were eradicated from the study area prior to planting. Soil is a shallow sandy-loam. Annual precipitation is about 16 inches and the elevation is 6,700 feet. This site is representative of extensive areas at intermediate and higher elevations now occupied by low value broadleaf evergreens.

A species adaptability planting was established in the fall of 1951. The planting included 30 grasses, 8 forbs, and 11 shrubs. In the spring of 1952, 24 grass species produced fair to good seedling

stands. Six of the forbs tested produced poor seedling stands and two failed. All shrub species with the exception of bitterbrush failed. By the summer of 1956, 10 grass species rated good or better, but only intermediate wheatgrass, pubescent wheatgrass, and bluebunch wheatgrass appeared vigorous. On one plot, creeping wildrye (Elymus triticoides) was spreading rapidly and this species was the most vigorous of all grass species in 1956 although seedling stands of creeping wildrye produced from the seed planted in the fall of 1951 were very poor. Several wild patches of this grass are spreading very rapidly on adjacent land.

Subsequent plantings in the fall of 1953, 1954, and 1955 resulted in good seedling stands for most species. Most of these seedlings perished during the dry summer months of the first year. Species which have produced the best established stand in the later plantings are intermediate wheatgrass, pubescent wheatgrass, tall wheatgrass, Secale montanum, and native Stipa.

Competition for moisture appears to be the major limiting factor. However, drought tolerant species such as crested wheatgrass and Indian ricegrass have not produced stands comparable to intermediate wheatgrass or pubescent wheatgrass. Seed of most forbs and shrub species germinated and emerged but seedling plants usually died within 2 to 3 weeks.

There may be a lack of macronutrients or micronutrients but this area was included in the pot fertility tests which indicate that nitrogen is in short supply. The area treated with lime could

be picked out in the spring months but this difference was not visible on July 15. It is quite likely that the rapid drying of the soil in conjunction with the high diurnal temperature change produces conditions unfavorable for plant growth. Species doing best on this site were native or the large seed plants with fast growing seedlings.

On September 29, 1957 the following species from the fall of 1955 planting appeared to be dead.

Agropyron cristatum
" desertorum
" sibericum
Bromus inermis
Dactylus glomerata
Elymus junceus
Hordeum bulbosum
Stipa viridula

II-B. ARTIFICIAL REVEGETATION IN THE SHADSCALE ASSOCIATION

Desert rangelands of the Intermountain region have been seriously depleted. At present there is urgent need to rehabilitate vast areas of these ranges to stop further deterioration by wind and water erosion, to stop deposition of sediment in lakes, reservoirs, and river basins like the Colorado and Virgin, to control noxious weeds, and to increase forage production, especially on winter ranges. This type occurs mainly toward the southern and southwestern parts of the Intermountain region. The largest continuous area extends from the Carson Desert of west-central Nevada, south and east to the dry mountain region of Death Valley and southern Nevada. A second large area lies in the arid portions of western Utah. A third is located in the Green and Colorado River drainages of eastern Utah and western Colorado. Isolated islands of this type extend northward into eastern Oregon, southern Idaho, and southwestern Wyoming.

In general, it can be said that the climate of this zone is drier than in the sagebrush zone. Mean January temperatures in the shadscale zone appear to be higher than in the sagebrush zone. The summer temperatures of the shadscale type in western Nevada are distinctly higher, about 5°F., than those in the sagebrush zone. The higher summer temperatures in the shadscale zone is undoubtedly reflected in higher evaporation, resulting when coupled with lower precipitation in greater aridity.

1. Churchill Valley - 16 miles from Virginia City, Nevada

The native vegetation on this site consists of Atriplex confertifolia mixed with little greasewood (Sarcobatus baileyi). The soil contains a high percentage of fine sand, is free from gravel or hardpan to a depth of 18 inches, but contains a few weathered volcanic rocks even on the surface. Soil of this texture does not puddle readily so can be worked even when wet.

The average annual precipitation on the study area is estimated to be between 5 and 8 inches or just a little better for plant growth than the average for the shadscale association. Precipitation from Sykes gages from March 26 to September 28, 1956 is shown below.

Date	Precipitation (inches)
March 26	Gages out
April 24	.66
May 2	.18
May 15	.81
June 5	.22
September 28	1.85
Total	3.72

The first planting on this area was made in the fall of 1943. Other early plantings were made in the spring of 1944 and fall of 1947. Some species produced fair stands but all planted species were dead by May 3, 1950. Death probably resulted from heavy utilization

by rodents and drought but detailed information is not available. Additional plantings were made in January 1953, November, 1953, December 1954, and March 1956 to determine adapted species and suitable methods for use in the shadscale association. Seed germination from these four plantings was erratic and unpredictable from one year to the next.

The planting in 1953 included 13 selected grasses and shrubs. Precipitation during the winter and early spring months of 1953 was not adequate for seed germination. On April 21 the soil was dry to a depth of 4 inches. Rains in late May 1953 resulted in good seed germination. Subsequent storms in June were favorable for rapid growth but most of the seedlings perished in the dry summer months which followed from drought or heavy utilization by rodents.

A rodent exclosure was built in the fall of 1953 and 16 grasses, 3 shrubs, and 8 forbs were planted on November 13, 1953. Most species germinated in late March and early April of 1954, but many species were dry and brown by early June. Many of the wheatgrasses and a few of the other species produced fair to good stands (Refer to 1954 Annual Report). By August 17 most grass plants were dormant or dead but many forbs and shrubs were still green. Only 0.63 inches of rain was measured from June 16 to December 9, 1954.

Thirteen grass species, 3 forbs, and 9 shrubs were planted in each of two replications on December 9, 1954. A drought began in July 1954. On March 31, 1955 the soil was loose and dry from

0 to 3 inches and the soil was only slightly damp from 3 to 12 inches. On this date seed from the 1954 planting had not germinated. Only .45 inches of precipitation was measured during the period April 1 through August 15. All species from the planting which germinated in the spring of 1953 and were still living in 1954 plus all species germinating in the spring of 1954 perished during this period of drought.

Due to lack of precipitation there was no seed germination from planted species, native perennials or annuals such as Russian thistle in the spring or summer of 1955. On August 15, seeds from selected species were removed from plots planted in December 1954. Seed was separated from the soil by digging along the row with a pocket knife. Seventy-five seeds were taken from each plot sampled. A total of 150 seeds was obtained for each of 4 selected grasses. Seed of each species was divided into three equal samples containing seeds. Three 50 seed samples were also taken from the same stock seed supplies which had been planted in the plots in the fall of 1954. Each sample was placed on special germination paper and germinated at room temperatures. Good germination resulted from all tests. The number of seeds germinating are shown in the 1955 report. A total of 1.42 inches of rain was measured following the storm which began on September 17 and ended on September 24. These rains provide ample moisture for seed germination and many species planted in the fall of 1954 germinated and produced fair seedling stands in September or

October 1955. Most of the plants that emerged came up between the cracks in the soil crust. Crusting was probably due to high intensity rains, followed by high temperature and rapid drying of the soil surface. Most plants lacked vigor and were thread-like in appearance.

By the spring of 1956 most of the seedlings present in the fall of 1955 had disappeared. Additional seed germination and emergence produceda few seedlings in the spring of 1956 but a heavy soil crust kept most of the germinated seedlings from emerging.

Additional plantings were made in Churchill Valley on March 10, 1956. Soil from 0 - 3 inches was quite dry on this date. On April 24 many seeds had germinated but most of the seedlings could not break through a crust on the soil which formed following a heavy rain on April 15. A rainstorm on April 26 and 27, which produced .17 inches failed to break the crust and on May2 many seeds had germinated but only a few had come up through cracks in the crust. Leaves on many seedlings were folded back or had extended horizontally under the crust. This soil dries very rapidly due to the prevailing winds and low humidity. Most of the seedlings examined that had not been able to break through the crust were yellow but a few were green. Apparently some sunlight was getting through the crust and chlorophyll in the leaves produced the green color.

On May 10 a storm producing .94 inches softened the crusts and many of the grass and shrub seedlings emerged. Species plots were rated on September 28, 1956. Plot ratings, number of plants

per linear foot of row, distribution rating, and plant height are shown in table 2. Rains in mid-September had produced some flooding. Crested wheatgrass, intermediate wheatgrass, pubescent wheatgrass, and Russian wildrye plants on low spots within the planting were green and growing. Most of the other plants were dry and brown and some appeared to be dead.

Shrub species were planted in the spring of 1953, fall of 1953, fall of 1954, and spring of 1955. Seedlings of fourwinged saltbush were obtained in 1953 and 1954. Winterfat seedlings were obtained in 1954. All of these plants died during the prolonged drought beginning in the late spring of 1954 and continuing until the fall of 1955.

Shrub species planted in the fall of 1954 failed to germinate in the spring of 1955 due to the lack of moisture. Precipitation coming on September 17, 1955 resulted in germination and emergence of two lots of fourwing saltbush but other species failed to emerge. Additional shrubs were planted in March 1956. In the spring of 1956 moisture was adequate for germination of two lots of fourwing saltbush and Gardner saltbush, Shadscale, one additional lot of fourwing saltbush, little greasewood, bud sagebrush, spiny hopsage, and winterfat failed to emerge.

Seedlings of native shadscale and native little greasewood from wild seed were found on the area in the spring of 1953 and 1954. These native shrubs were planted in the fall of 1954 and 1955 but

Table 2. Relative plot rating, plants per linear foot of row, distribution rating and average height of seedling stands from a planting made on March 10, 1956.

Plot No.	Species and Lot	Relative Rating[1]	No. Plants[2]	Dist. Rating[3]	Average Ht.(in.)
	Grasses				
204	Agropyron cristatum	6	0.6	2	3
208	32013	8	1.0	4	4
101	Agropyron "	3	0.4	1	3
409	32032	2	0.2	1	3
201	Agropyron desertorum	9	1.6	4	3
307	31976	8	0.9	4	4
202	Agropyron "	9	1.2	4	4
308	32628	9	1.4	4	4
302	Agropyron "	9	1.7	4	4
209	32658	9	1.7	4	4
104	Agropyron "	5	0.6	2	4
410	32661	9	1.3	4	4
102	Agropyron "	6	0.7	3	3
310	33007	8	0.9	4	4
203	Agropyron "	6	0.7	3	3
309	33008	7	1.2	3	3
301	Agropyron "	6	0.7	3	3
207	33009	7	0.9	3	4
501	Agropyron inerme	7	1.0	3	3
111	33010	3	0.4	1	4
403	Agropyron intermedium	8	1.3	4	5
107	32058	9	1.6	4	5
103	Agropyron sibiricum	5	0.6	2	4
311	32060	5	0.6	2	4
502	Agropyron trichophorum	4	0.4	2	5
108	31975	9	2.0	4	5

Plot No.	Species and Lot	Relative Rating[1]	No. Plants[2]	Dist. Rating[3]	Average Ht.(in.)
	Grasses (cont.)				
404	Agropyron trichophorum	9	1.2	4	6
210	32014	9	1.3	4	5
401	Agropyron "	9	1.4	4	5
109	32126	10	2.3	5	6
402	Agropyron "	4	0.4	2	5
110	33024	9	1.4	4	6
505	Agropyron triticeum	6	0.9	3	4
510		4	0.4	2	4
205	Bromus breviaristatus	10	2.0	5	4
507		9	1.6	4	5
303	Elymus junceus	3	0.3	2	3
113	32018	2	0.2	1	4
304	Elymus "	8	1.3	4	4
112	33014	9	1.4	4	4
405	Oryzopsis hymenoides	10	3.0	5	6
213	43	10	3.3	5	6
305	Oryzopsis "	6	0.7	3	4
212	44	9	1.5	4	3
406	Oryzopsis "	8	1.0	4	5
312	46	10	2.0	5	6
306	Oryzopsis "	5	0.6	2	5
211	54	7	0.9	3	5
504	Sitanion hystrix	1	0.2	-	3
509	30	7	1.0	3	3
503	Sitanion "	1	0.1	-	2
411	31	2	0.2	1	3
506	Stipa x Oryzopsis	6	0.7	3	5
313		8	1.4	4	5

Plot No.	Species and Lot	Relative Rating[1]	No. Plants[2]	Dist. Rating[3]	Average Ht.(in.)
	Forbs				
105	Erodium cicutarium	6	0.7	3	3
407	N1	6	0.7	3	5
206	Kochia indica	6	0.5	2	10
408	N1	7	0.5	3	8
106	Kochia scoparia	6	0.4	2	14
508	1	3	0.2	1	8

1. Relative ratings are based on summation of ratings for plant numbers and distribution. 1-2 very poor; 3-4 poor; 5-6 medium; 7-8 good; 9-10 very good.

2. No. Plants - Number of plants per linear foot of row.

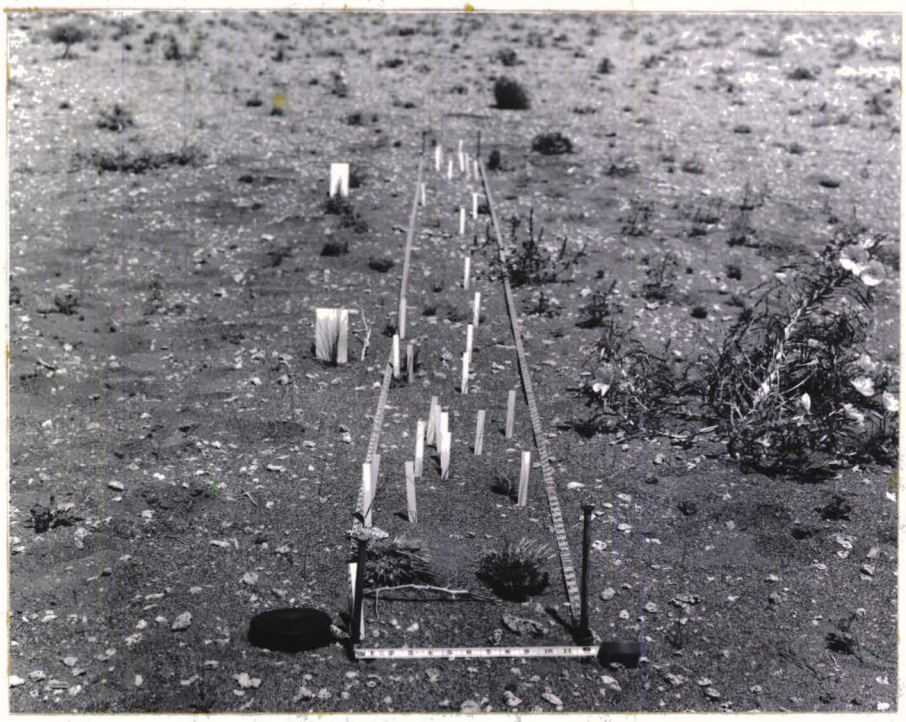
3. Distribution: 1 very poor; 2 poor; 3 medium; 4 good; 5 very good.

no germination or emergence was observed. This was probably due to the very dry spring in 1955 and the heavy soil crust in 1956. No mortality of established native shrubs was observed during the drought. Planted shrubs which had emerged perished during this period.

2. Fernley

The 1954-1955 drought apparently resulted in a high death loss to native Sitanion hystrix and Oryzopsis hymenoides plants in west central Nevada. For example, O. hymenoides had a total plant count of .7 plants per square foot on the old abandoned Fernley Airport in the spring of 1954. On November 5, 1955 only 4 percent of these plants were living. On this date regrowth was 2 - 3 inches long. Russian thistle plants were 1 to 4 inches high as a result of moisture coming on about September 17, 1955.

This area appeared to be nearly devoid of vegetation during the early spring period in 1956. By midsummer the area was dominated by a stand of annual evening primrose, annual lupine, annual astragalus, annual franseria, and seedling plants of Indian ricegrass. Ten belt transects, each 50 feet long and 1 foot wide gave an average of 0.49 Indian ricegrass seedlings per square foot on this area on June 5, 1956. Number of plants per 50 square feet ranged from 12 to 53. Distribution of seedlings was quite uniform over the area (figs. 1 and 2). However, there did seem to be a loose clustering of seedling plants, presumably around seed producing



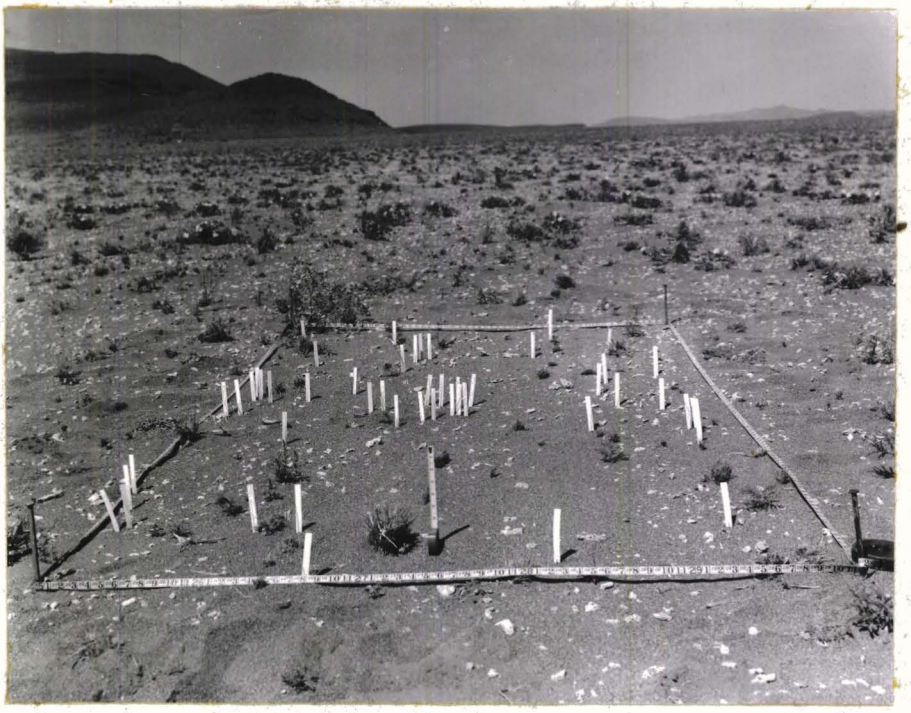


Figure 1 and 2 . White stakes mark the native Indian ricegrass seedlings in the spring of 1956 growing near Fernley, Nevada. Dead crowns of some of the old plants killed during the 1954 and 1955 drought can be seen in the foreground. Note the clusters of seedlings on the left of the upper photo from seed caches, presumably, made by rodents (B56-57 and B56-58).

parent plants, and a definite clustering of a large number of seedlings in small pockets, presumably from rodent seed caches (fig. 3).

A total of 385 Indian ricegrass seedlings were dug out and the distance from the soil surface to the germinated seeds was measured (fig. 4). The average depth to the germinated seed was 2.2 inches or 5.1 centimeters. The minimum depth was less than 1 centemeter (0.4 inches) and the maximum depth 10.1 centimeters (3.9 inches). The viable seed crop on this area was very small in 1954. In 1954 a good seed set was made on this area but most of the seeds failed to mature. Most of these seeds collected were empty. However, the viable seed content was good on Indian ricegrass plants growing in the barrow pits on each side of the highway, which goes through this area. In 1955 no viable seeds could be found on this area except where additional moisture was available due to the shading, drainage, or similar conditions. Presumably, most of the seed germinating in the spring of 1956 came from seed produced prior to 1955. Similar findings on other study areas have shown that Indian ricegrass seed can lay dormant in the soil for at least 6 years.

3. Gondra Ranch - 13 miles southeast of Paradise Valley, Nevada

The shrubby vegetation on the study site was made up of bud sagebrush (Artemisia spinescens) and shadscale (Atriplex confertifolia) occurring at a rate of 1 plant per 2.5 square feet

Figure 3 . A cluster of seedlings of Indian ricegrass growing from a seed cache, presumably, made by rodents (B56-56).

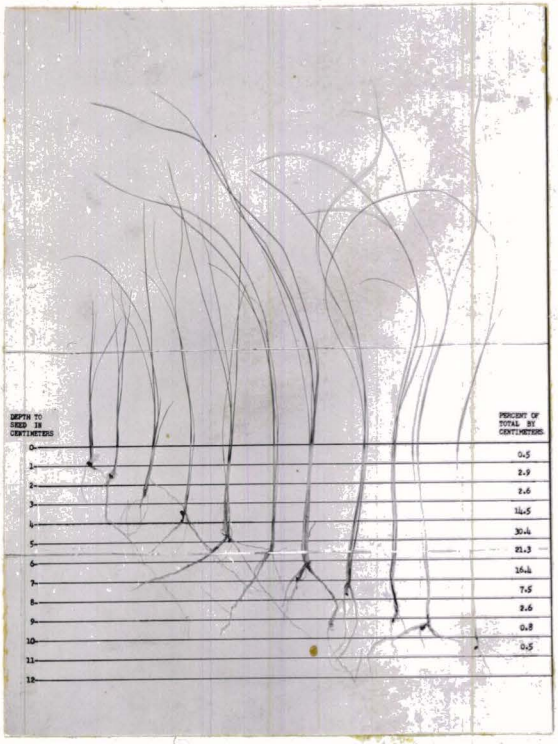


Figure 4 . Native seedling plants of Indian ricegrass growing near Fernley, Nevada showing depth from soil surface to seed and percent of plants growing from each depth. Mean depth to germinated seed was about 5 centimeters (B56-124).

and 4.0 square feet, respectively. A few weak, severely grazed plants of Oryzopsis hymenoides were found. Sitanion hystrix, although not present on the study site, was sparsely represented on adjacent land.

In the summer of 1946 the native vegetation was grubbed. The study was divided into 10 14x40 foot plots on each of 2 replications. The following species were planted: Agropyron cristatum, A. desertorum, A. elongatum, A. inerme, A. intermedium, A. sibericum, A. trichophorum, Elymus junceus, E. salina, Oryzopsis hymenoides, and Sitanion hystrix. These species were drilled into the plots on December 12, 1946. This area was rabbit fenced in July 1947. Refer to 1955 report for plot ratings of planted species in 1947, 1948, 1954, and 1955 and air-dry yield in 1948, 1954, and 1955. Adaptability and behavior of these species on smaller adjacent row plots substantiate the results observed on the larger plots.

All plants of intermediate, tall wheatgrasses and most plants of pubescent wheatgrass died prior to 1954. These species are not adapted to the shadscale association although good seedling stands have been obtained. Other studies have shown that these grasses are not well adapted to the lower portion of the sagebrush type. Pubescent wheatgrass appeared to be able to withstand drier conditions than intermediate or tall wheatgrass in the Intermountain region. Planting of these grasses and crested wheatgrass were made

in pure stands and in mixtures with each other on nearby land in Paradise Valley which is considered to be in the lower half of the sagebrush type. Crested wheatgrass was superior to the other wheatgrasses, as shown in figures 5 to 8.

Native shrub species have come in on all plots in this area, especially on those plots which had been planted to intermediate wheatgrass, tall wheatgrass, pubescent wheatgrass, and Elymus salina. Atriplex confertifolia (fig. 10) is much more abundant within the exclosure which was clear grubbed in the fall of 1946 than the Artemisia spinescens (fig. 9). The A. spinescens is most abundant on the uncleared area surrounding the exclosure.

Crested wheatgrass plants have reseeded themselves and plants have invaded other plots. In 1953 crested wheatgrass plants were of several sizes and age classes. A good seedling stand was produced in 1953, but no seedlings could be found in 1954.

In 1954 there were many dead plants of crested wheatgrass, Sibericum wheatgrass, bluebunch wheatgrass, and a few dead plants of Russian wildrye. Good seed could not be found in the seed heads pro duced in this year.

In 1955 all species except two lots of A. desertorum and Elymus junceus appeared to be completely dead on June 23, 1955. About 90 percent of the plants of these species also appeared to be dead on this date. Good seed could not be found in the seed heads produced in 1955. Also, native grasses did not make appreciable growth and many of these plants appeared to be dead. The

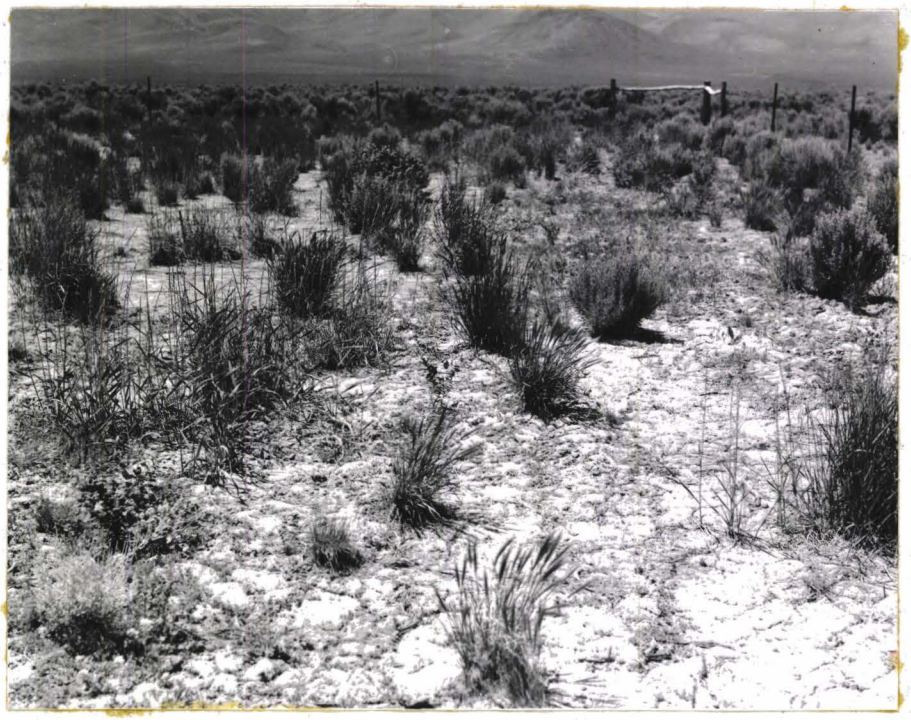


Figure 5. These plots in the lower sagebrush type were planted with pubescent wheatgrass as the principal species (B56-67) - compare with Figure 8.

Figure 6. These plots in the lower sagebrush type were planted with tall wheatgrass as the principal species (B56-68) - compare with Figure 8.

Figure 7 . These plots in the lower sagebrush type were planted with intermediate wheatgrass as the principal species (B56-69). Compare with Figure 8 below.

Figure 8 . In the lower sagebrush type crested wheatgrass has maintained good stands (B56-70). Compare with Figures 5 , 6 and 7 where intermediate wheatgrass, pubescent wheatgrass and tall wheatgrass were planted on adjoining plots.

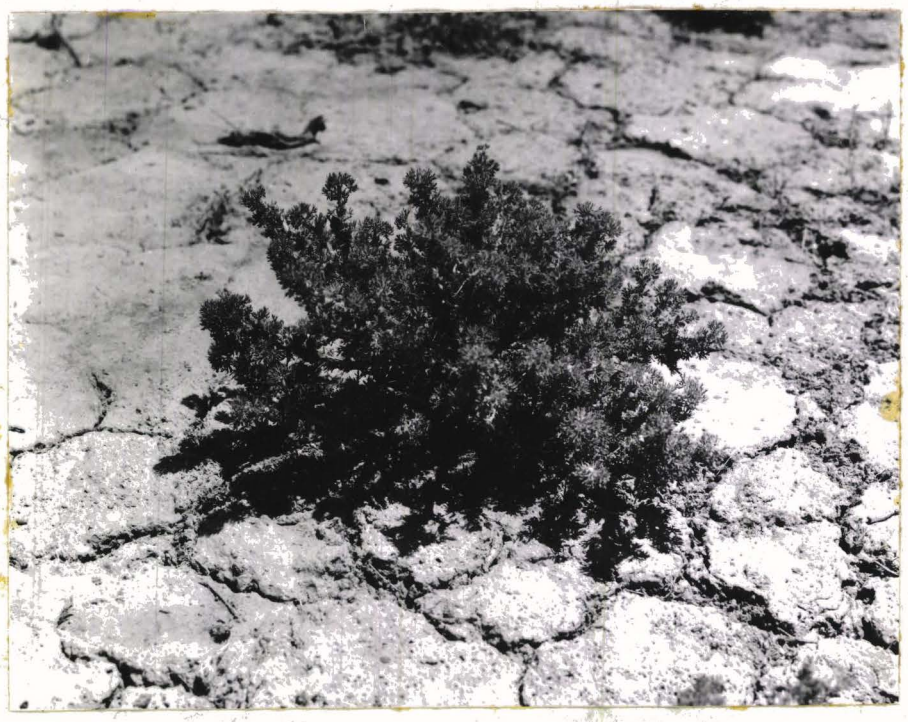


Figure 9. A vigorous plant of bud sagebrush (Artemisia spinescens) growing within the exclosure on the Gondra Ranch in Paradise Valley, Nevada (B56-62).

Figure 10. A vigorous plant of shadscale (Atriplex confertifolia) growing within the exclosure on the Gondra Ranch in Paradise Valley, Nevada (B56-66).

Atriplex confertifolia and Artemisia spinescens made very little growth but no death loss due to drought was observed. A few halogeton plants were found near the exclosure but they were small and showed effects of drought.

In 1956 approximately 10 percent of these plants had 1 or 2 culms within the original crown which showed some sign of life (table 3). Some of the living crested wheatgrass and Russian wildrye plants can be seen in figures 11 and 12. Most of the old living crested wheatgrass plants produced good seed. Seedling plants of crested wheatgrass, Siberian wheatgrass, and Russian wildrye and native Indian ricegrass could be found in the exclosure. Plants on the original Siberian wheatgrass plots were considered to be this species and not crested wheatgrass. Crested wheatgrass seedlings were found on adjoining plots but only those within the original plots are shown in table 3. Some of the seedling crested wheatgrass plants can be seen in figure 13. A few seedlings of native Indian ricegrass could be found on all plots. Most of the old native ricegrass plants on this area were green and growing. Although mortality of shrubs could not be seen in 1954 or 1955 some of the young bud sagebrush plants were dead in 1956 where competition from other shrubs or grasses was severe.

Table 8 . Number of volunteer seedlings and old living plants in the spring of 1956 after the drought in 1954 and 1955.

Plot No.		Lot	Number of plants per sq. ft. Old	Seedlings
101	Agropyron desertorum	GS-43	.07	0.30
301	Agropyron desertorum	GS-43	.01	0.03
205	Agropyron desertorum	2	.05	0.42
405	Agropyron desertorum	2	.06	0.55
201	Agropyron elongatum	P-2326	-	-
303	Agropyron elongatum	P-2326	-	-
102	Agropyron inerme	PV47	-	-
403	Agropyron inerme	PV47	-	-
202	Agropyron intermedium	P-2327	-	-
302	Agropyron intermedium	P-2327	-	-
105	Agropyron sibericum	10	0.00	0.07
305	Agropyron sibericum	10	0.02	0.03
204	Agropyron trichophorum	11	-	-
304	Agropyron trichophorum	11	-	-
103	Elymus junceus	PV46	.04	0.01
404	Elymus junceus	PV46	.03	0.00
104	Elymus salina	PV46	-	-
402	Elymus salina	PV46	-	-
203	Oryzopsis hymenoides	PV46	-	-
401	Oryzopsis hymenoides	PV46	-	-
	Sitanion hystrix	PV46	-	-

Figure 11. Marked crested wheatgrass plants contain one or more living culms, all other crested wheatgrass plants from the 1946 planting perished during the 1955 drought (B56-65).

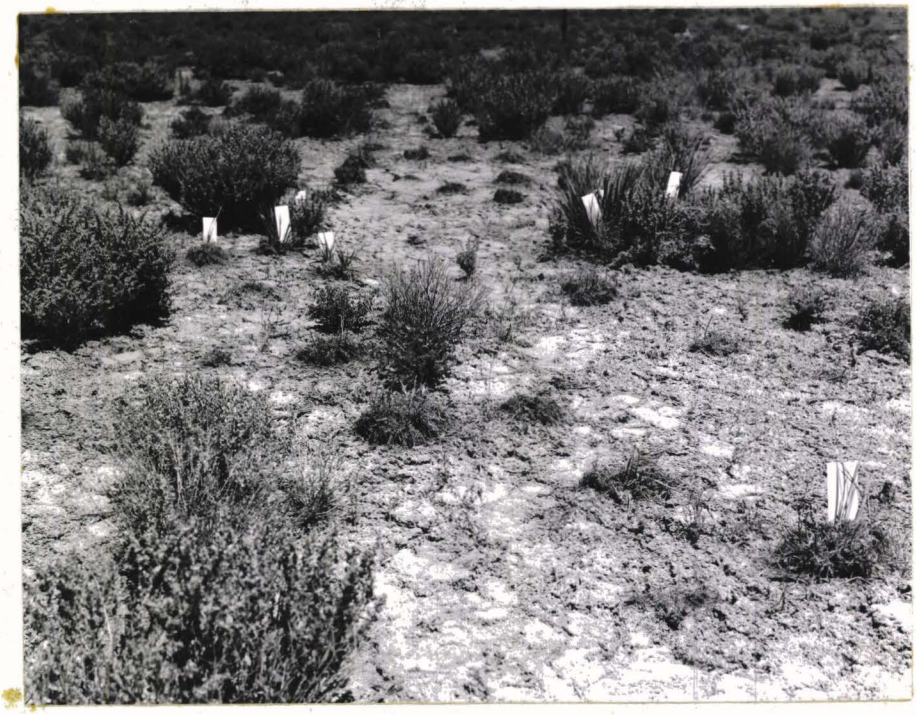


Figure 12. Marked Russian wildrye plants contain one or more living culms, all other plants from the 1946 seeding perished during the 1955 drought (B56-63).

Figure 13 . In the spring of 1956 seedling plants of crested wheatgrass, marked by the white stakes, were growing around the old plants which were killed or damaged by the 1955 drought (B56-64). See Figure 11 .

4. Utah Shadscale Association Trials

There have been many plantings made in the Shadscale Association in Utah. Native vegetation on these areas include winterfat, shadscale, galleta grass, black sagebrush, greasewood, fourwing saltbush, yellowbrush, Gardner saltbrush, mat saltbrush, and others. Most of these plantings are on Bureau of Land Management Land or on private property.

Several plantings were made in western Utah, some in central Utah and some in southeastern Utah, within the Colorado River drainage. Average annual precipitation in this type ranges from about 5 to 9 inches. Many of the earlier plantings were made by the Grazing Service, but there is no record of methods or species used. Occasional plants of crested wheatgrass, growing under the protection of a shadscale or similar shrub, are all that remain of many of these studies (fig. 14). A rather successful planting of crested wheatgrass was made into a stand of winterfat west of Milford, Utah in the fall of 1939 by A. P. Plummer. One of the best plantings was made by Mr. Victor Murray at Cisco, Utah. An 18 acre field was planted to crested wheatgrass in the spring of 1938. In 1952 most of the plants appeared thrifty but by 1955 most of these plants had perished under light grazing use by horses.

In general, poor results were obtained by species of Sporobolus, Bouteloua, and Hilaria, all natural drought enduring grasses. Some fundamental studies will be required to learn how to get stands of these species as well as promising shrub species. The principal reason for failures appears to be the unpredictable and low precipitation.

Figure 14. Crested wheatgrass plants are frequently found growing under shadscale plants. Shading and protection from grazing by the shadscale apparently more than compensates for the competition for available moisture. (B56-106)

II-C. PRELIMINARY EVALUATION OF SITE FACTORS IN THE UPPER SAGEBRUSH TYPE

This study was made on an area within the Ruby Valley Substation near Wells, Nevada. The plot is 45 x 100 yards in extent. It occupies the west side of a dry creek, the southeast slope above the creek and the bottom of the small drainage entering from the west (fig. 15). This area was originally selected to determine the effectiveness of a mixture of selected species in revegetating an extremely variable site in the sagebrush type and determine the range in adaptability of the component species.

Site factors are the environmental conditions affecting the plants at a certain place and time. Climate, soil, and organisms are the major controlling factors. Each of these can be divided in component parts such as light, temperature, humidity, and precipitation; soil depth, fertility, texture and structure; insects, disease organism, birds, grazing animals, and man. The isolation and evaluation of any one factor is difficult due to the interaction of forces. It is the purpose of this study to compare the data from three sites and attempt to explain difference and similarities by existing environmental conditions.

This area was burned over by a wildfire on August 14, 1940. Prior to this burn the lower portion of the area supported big sagebrush plants 4 to 6 feet tall, an indication of the depth and productive capacity of the soil. On the lower part of this plot, the original grasses were Elymus condensatus, Poa nevadensis, Stipa

Figure 15 . General view of the preliminary site factor study near Wells, Nevada (B56-81).

columbiana, and a small amount of Agropyron trachycaulum. On a north facing slope Bromus carinatus and Festuca idahoensis were present. On the drier slopes Oryzopsis hymenoides, Sitanion hystrix, P. secunda, and A. spicatum were the principal grasses present.

Based on the character of the soil, topography, native vegetation, and the results of species trials at the Ruby Substation at that time, the species listed below were selected. The seed was mixed, broadcast and covered by harrowing on October 16, 1940. This study was established by Dr. J. H. Robertson.

Species	Lot No.	Pounds/acre
Agropyron desertorum	17	3
" trachycaulum	12 & 21	2
" smithii	15	1.5
Arrhenatherum elatius	8	2
Bromus inermis	10 & 15	2
Elymus canadensis	6	2
Melilotus officinalis	1	1
Phalaris arundinacea	2	1
Poa bulbosa	1	2
" ampla	4	0.5

In 1942, three transect clusters were established on this area as shown in figures 16 and 17. One cluster is in the swale, one is located on the dry hillside and one is intermediate between

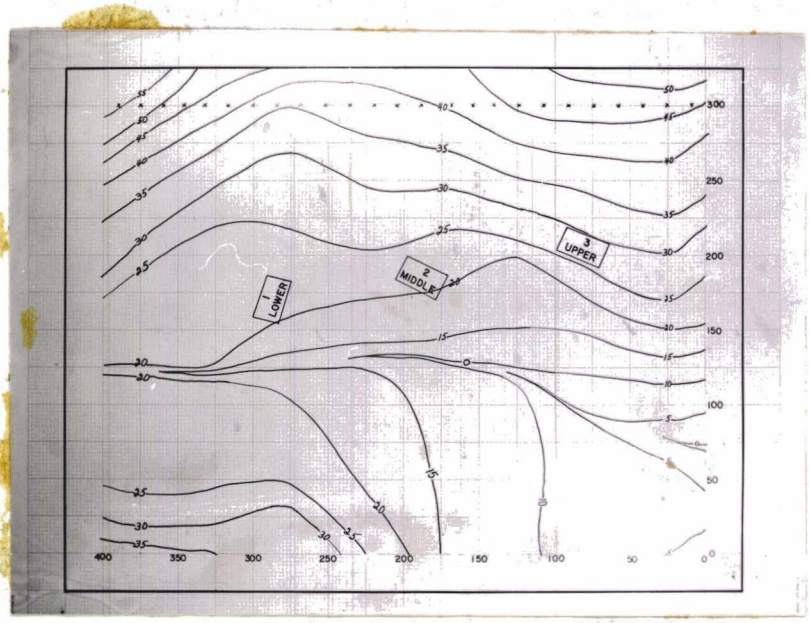


Figure 16 . Location of the transect clusters and a contour map showing topography of the area (B56-128).

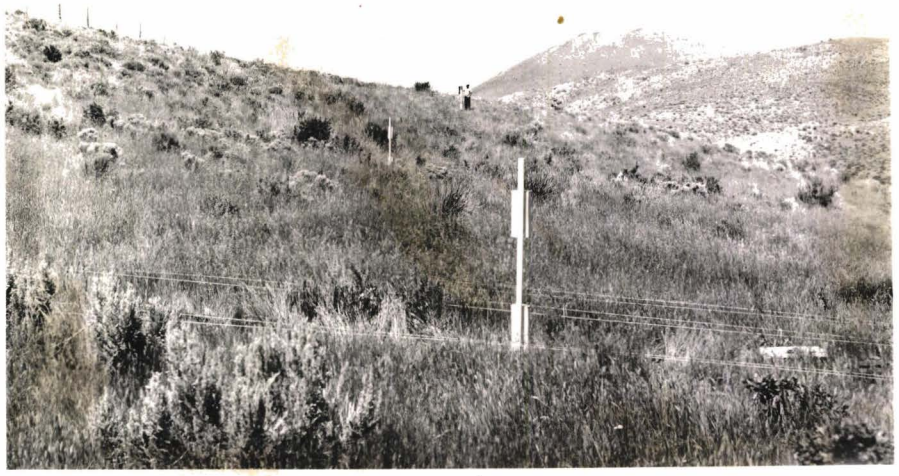


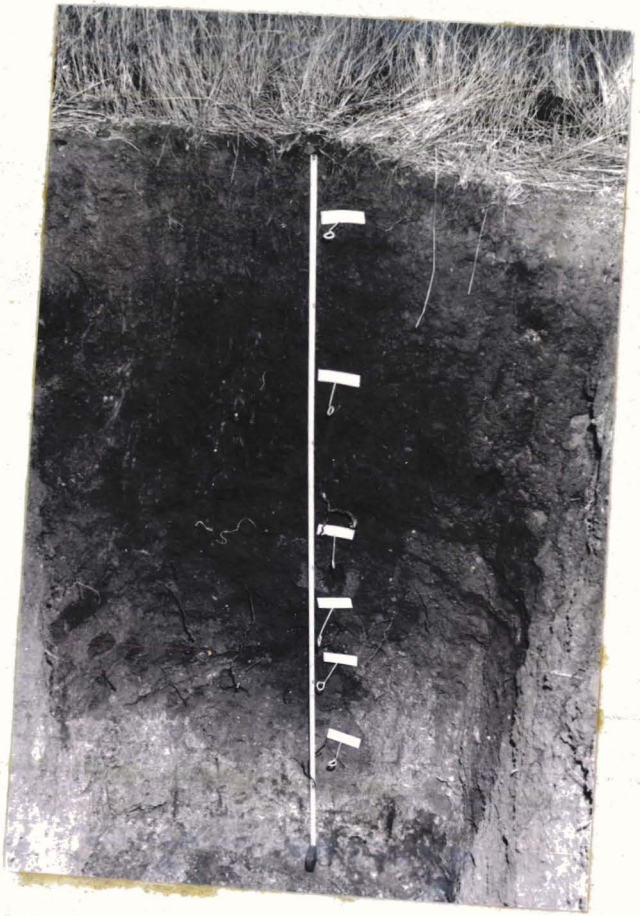
Figure 17 . The white stakes mark the location of the transect clusters within this area (B56-79).

the swale and the hillside. Data have been collected on this study at intervals from 1942 to 1956. In 1956 the following data or material was collected on the transects at the three locations.

1. Number of plants of each species
2. Basal area by species
3. Yield by species
4. Average height by species
5. Number of crested wheatgrass plants by size classes.
6. Number of flower stalks produced by crested wheatgrass
7. Soil samples and soil profiles
8. Soil moisture content at 0-6, 6-18, and 18-30 at intervals during the growing season
9. Soil temperatures at depths of 1 and 6 inches and air temperatures at 12 and 48 inches above the ground were taken every 4 hours for 2 consecutive days.

After 16 years all portions of this area were dominated by crested wheatgrass. Smooth brome and western wheatgrass made up about 5 percent of the herbage in the swale but were only present in trace amounts on the drier slopes. Big bluegrass was found only on the lower and middle transects but a few plants were seen near the upper transect. Yield of crested wheatgrass and total yield decreased sharply from the drainage to the hillside. Leaf and flower stalk height, number of flower stalks per plant and average size of plants increased from the drainage to the dry hillside.

Soil samples were made in pits which crossed the transect clusters at each location (figs. 18, 19, and 20). Soil samples were taken by E. A. Naphan, D. G. Bagley, and A. T. Bleak. Soil descriptions for the three soils sampled at the Ruby Substation in September were prepared by Mr. E. A. Naphan, State Soil Scientist, Soil Conservation Service, Reno, Nevada. Copies of these soil descriptions are attached.



Figures 18 , 19 and 20 . A view of the soil pits on the lower, middle and upper study areas (B56-82, B56-83, and B56-87).

ARS Plot BCX 44 Lower
S56-Nev-9-1-1 through 10
September 26, 1956

Ruby Loam (Tentative Soil Series)

Described by: E. A. Naphan

Sampled by: E. A. Naphan, D. G. Bagley, A. T. Bleak

Location: U. S. Forest Service Clover Creek Station; ARS forage research plot "BCX 44 Lower". Station is located in Elko County approximately 6 miles west of Wells, Nevada; approximately 2 miles south on Willow Creek road from Cozier Ranch.

Elevation: Approximately 6300 feet

Topography: Narrow stream bottom along small intermittent stream. Slope about 3-4%.

Drainage: Well drained at present due to entrenchment of channel. Soil probably developed under moderately well drained condition. Ground water table fluctuates at approximately 6-12 feet. The permeability of the soil profile is moderate to moderately rapid throughout.

Vegetation: Original vegetation consisted of native perennial grasses and shrubs. The site was seeded on a burn in 1940. The composition of the present vegetation is as follows:

Crested wheatgrass (Fairway Strain)	90%
Western wheatgrass Smooth brome Big bluegrass	1%
Bitterbrush Rabbitbrush Horsebrush Big sagebrush	8%

Poverty weed)
) 1%
Arrowleaf balsamroot)

Plant density is about 0.65.

Use: The plot is used cooperatively by the Field Crops Research Branch, ARS, Forage and Range Section and University of Nevada Experiment Station. For site factor studies in connection with revegetation investigations on range land. It has had only limited grazing use by horses.

Parent Material: Loamy alluvium derived from shale, quartzite, gneiss, and some limestone and basalt.

Climate: Mean annual rainfall 12-15 inches, and a mean annual temperature of 45°F. Most of the rainfall comes as snow during winter months.

Other Features: The site is located approximately 50 feet from the creek channel at the foot of a small alluvial fan. The soil profile was dry to approximately 60 inches at time of sampling. Below 60 inches the moisture content was above the wilting coefficient and increased with depth. No water table was encountered within a depth of 10 feet at the time of sampling.

Soil Profile

Ruby Loam

(S56-Nev-4-1-1) A_{11} 0-3½" Black (10YR 2/1) loam, very dark gray (10YR 3/1) when dry containing 10-15% subangular chert and quartzite gravel ⅛-2cm in size; weak very fine platy breaking to moderate very fine granular; soft, friable and nonsticky; many fibrous grass roots tend to form sod; ph 8.4 with thymol blue (1:5); noncalcareous; clear smooth lower boundary.

(S56-Nev-4-1-2) A_{12} 3½-7½" Black (10YR 2/1) loam, very dark grey (10YR 3/1) when dry. Weak fine granular; soft friable and nonsticky; many fine fibrous roots and a few coarse fibrous roots; ph 8.4 with thymol blue (1:5); noncalcareous, clear smooth lower boundary.

(S56-Nev-4-1-3) A_{13} 7½-17½" Very dark grey (10YR 3/1) loam, dark grey (10YR 4/1) when dry. Weak to moderate medium subangular blocky; slightly hard, friable, and nonsticky; numerous fine fibrous roots and few coarse fibrous roots; ph 8.4 with thymol blue (1:5); noncalcareous; abrupt wavy lower boundary.

(S56-Nev-4-1-4) C-1 17½-30" Very dark grey (10YR 3/1) gravelly loam with thin lenses of gravelly sand; dark grey (10YR 4/1) when dry. The gravelly sand comprises about 30-40% of this horizon and the gravel is subangular chert and quartzite. Weak medium subangular blocky; hard, friable and nonsticky; numerous fine fibrous roots; ph 8.5 with thymol blue (1:5); noncalcareous; abrupt smooth lower boundary.

(S56-Nev-4-1-5) C-2 30-35" Very dark grey (10YR 3/1) loam streaked and stratified with dark grey (10YR 4/1) very fine sandy loam. The loam is grayish brown (10YR 5/2) and the very fine sandy loam light grey (10YR 7/2) when dry. Weak to moderate coarse subangular blocky; hard, friable and nonsticky; few fine fibrous roots; ph 8.5 with thymol blue (1:5); noncalcareous; abrupt smooth boundary.

(S56-Nev-4-1-6) C-3 35-41" Black (10YR 2/1) loam with about 15-20% subangular chert and quartzite gravel. Massive in place and weak medium granular when removed; slightly hard, very friable and nonsticky; few fine fibrous roots; ph 8.6 with thymol blue (1:5); noncalcareous; clear wavy lower boundary.

(S56-Nev-4-1-7) C-4 41-45½" Very dark brown (10YR 2/2) loam with few coarse faint dark yellowish brown (10YR 3/4) mottles in root channels. Massive in place breaking to weak coarse subangular blocky; slightly hard, friable, and slightly sticky; few fine fibrous roots; ph 8.7 with thymol blue (1:5); noncalcareous; clear wavy lower boundary.

(S56-Nev-4-1-8) Cca-1 45½-60" Black (10YR 2/1) loam with common medium distinct white (10YR 8/1) lime mottles; massive in place breaking to weak coarse subangular blocky; very few fine fibrous roots; ph 8.7 with thymol blue (1:5); calcareous; clear wavy lower boundary.

(S56-Nev-4-1-9) Cca-2 60-67" Very dark gray (10YR 3/1) loam with common medium faint (10YR 6/1) lime mottles; massive in place breaking to weak coarse subangular blocky; hard, friable and slightly sticky; very few fine fibrous roots; ph 8.8 with thymol blue (1:5); calcareous; clear wavy lower boundary.

(S56-Nev-4-1-10) C-5 67-80"± Very dark gray (10YR 3/1) loam, gray (10YR 5/1) when moist. Massive in place breaking to weak fine to medium subangular blocky; slightly hard, friable and slightly sticky; ph 8.8 with thymol blue (1:5); weakly calcareous; contains very few fine fibrous roots.

Remarks: This soil represents a fertile loamy soil with an estimated water holding capacity of approximately 8-9 inches for a 60 inch profile. Evidence indicates that grass and shrub roots have extracted significant amounts of water to a depth of 48-60 inches. It has a high organic matter content and developed under grassland vegetation.

ARS Plot BCX 44 Middle
S56-Nev-4-2-1 through 7
September 26, 1956

Alazon Gravelly Loam (Tentative Soil Series)

Described by: E. A. Nephan

Sampled by: E. A. Nephan, D. G. Bagley, A. T. Bleak

Location: U. S. Forest Service Clover Creek Station; ARS forage research plot "BCX 44 Middle". Station is located in Elko County approximately 6 miles west of Wells, Nevada; approximately 2 miles south on Willow Creek road from Cazier Ranch.

Elevation: Approximately 6300 feet.

Topography: Small alluvial cone peripherial to stream bottom. Slope about 14%.

Drainage: Somewhat excessive due to gravelly soil profile. Moderately rapid to rapid permeability throughout.

Vegetation: Original vegetation consisted of native perennial grasses and shrubs. The site was seeded on a burn in 1940. The composition of the present vegetation is as follows:

Crested wheatgrass (dominantly standard strain)	70%
Western wheatgrass Smooth brome Big bluegrass	1%
Bitterbrush Horsebrush Big sage	19%
Arrowleaf balsamroot Hawksbeard Lupine Poverty weed	10%

Plant density is about 0.30 - 0.40.

Use: The plot is used cooperatively by the Field Crops Research Branch, ARS, Forage and Range Section and University of Nevada Experiment Station for site factor studies in connection with revegetation investigations on rangeland. It has had only limited grazing use by horses.

Parent Material: Gravelly calcareous alluvium derived locally from the Miocene Humboldt Formation. The material is from mixed parent rocks among which limestone, shale, quartzite and basalt predominate.

Climate: Mean annual rainfall 12-15 inches, and a mean annual temperature of 45°F. Most of the rainfall comes as snow during winter months.

Other Features: The soil profile at time of sampling was dry to approximately 41 inches. Below 41 inches the moisture content was approximately 30% of field capacity. The ground water table is believed to be below 15 feet. Good plant litter is present and no active erosion is taking place.

Soil Profile

Alazon gravelly loam

(S56-nev-4-2-1)

A_{11} 0-5" Black (10YR 2/1) gravelly loam; very dark gray to dark gray (10YR 3/1 to 4/1) when dry. Subangular and angular chert and quartzite gravel 2 mm to 1 cm in size comprises 30-50% of this horizon. Massive in place breaking to weak very fine granular; soft, friable and nonsticky; many fine and few coarse fibrous roots; ph 8.4 with thymol blue (1:5); noncalcareous; clear smooth lower boundary.

(S56-Nev-4-2-2) A_{12} 5-18" Black (10YR 2/1) gravelly loam, dark grey (10YR 4/1) when dry. Contains about 30% subangular chert and quartzite gravel 3mm to 2cm in size. Massive in place breaking to weak medium subangular blocky; slightly hard, friable and nonsticky; numerous fine and few coarse fibrous roots; ph 8.4 with thymol blue (1:5); noncalcareous; clear smooth lower boundary.

(S56-Nev-4-2-3) Black to very dark grey (10YR 4/1 to 5/1) gravelly loam, dark grey to grey (10YR 4/1 to 5/1) when dry. Contains about 50% subangular chert and quartzite gravel 3mm to 2cm in size; massive in place breaking to weak medium subangular blocky hard, friable and slightly sticky; few fine and coarse fibrous roots; ph 8.6 with thymol blue (1:5); noncalcareous; clear irregular lower boundary.

(S56-Nev-4-2-4) A_{14} 33-41" Very dark grey (10YR 3/1) gravelly loam, gray (10YR 5/1) when dry. Contains about 50% chert and quartzite gravel. Massive in place breaking to weak medium and coarse subangular blocky; slightly hard, friable and slightly sticky; few fine and coarse fibrous roots; ph 8.6 with thymol blue (1:5); noncalcareous; clear wavy lower boundary.

(S56-Nev-4-2-5) A_{15} 41-47" Very dark gray to very dark grayish brown (10YR 3/1 to 3/2) gravelly loam. Contains about 20-30% subangular chert and quartzite gravel. Massive in place breaking to weak fine subangular blocky; few thin clay skins in root channels and gravel casts; slightly hard; very friable and nonsticky; few fine and coarse fibrous roots; ph 8.7 with thymol blue (1:5); noncalcareous; clear wavy lower boundary.

(S56-Nev-4-2-6) Cca$_1$ 47-55" Dark grayish brown (10YR 4/2) very gravelly loam, light brownish gray (10YR 6/2) when dry. Contains 60-70% gravel 2-5mm in size. Many medium faint white (10YR 8/1) lime mottles; massive in place breaking to weak fine subangular blocky; hard, friable and slightly sticky; few fine and coarse fibrous roots; ph 8.7 with thymol blue (1:5); highly calcareous and very weakly cemented with lime; gradual wavy lower boundary.

(S56-Nev-4-2-7) Dark grayish brown (10YR 4/2) very gravelly loam. Contains 60-70% gravel 2-5mm in size; many medium faint white (10YR 8/1) lime mottles; massive in place breaking to weak medium to coarse subangular blocky; hard, friable and nonsticky; very few fine and coarse fibrous roots; ph 8.7 with thymol blue (1:5); non-calcareous and very weakly cemented with lime.

Remarks: This soil represents a fertile soil with an available water holding capacity of approximately 5 inches for a 60 inch profile. It has a high organic matter content and developed under grassland vegetation.

ARS Plot BCX 44 Upper
S56-Nev-4-3-1 through 6
September 26, 1956

Tulasco gravelly Loam (Tentative Soil Series)

Described by: E. A. Naphan

Sampled by: E. A. Naphan, D. G. Bagley, A. T. Bleak

Location: U. S. Forest Service Clover Creek Station; ARS forage research plot "BCX 44 Upper". Station is located in Elko County approximately 6 miles west of Wells, Nevada; approximately 2 miles south on Willow Creek road from Cazier Ranch.

Elevation: Approximately 6300 feet

Topography: Rolling hills; site is on a southeast facing foot slope with a slope of about 22%.

Drainage: Well drained. Downward movement of water is moderately restricted by B horizon.

Vegetation: Original vegetation consisted of native perennial grasses and shrubs. The site was seeded on a burn in 1940. The composition of the present vegetation is as follows:

Crested Wheatgrass (dominantly standard strain)	85%
Western Wheatgrass Smooth brome Big bluegrass	0.5%
Bitterbrush Rabbitbrush Horsebrush Big sage	12%

Arrowleaf balsam root	2½%
Hawksbeard	
Lupine	
Poverty weed	

Plant density about 0.30 - 0.40

Use: The plot is used cooperatively by the Field Crops Research Branch, ARS, Forage and Range Section and University of Nevada Experiment Station for site factor studies in connection with revegetation investigations on range land. It has had only limited grazing use by horses.

Parent Material: Colluvia material derived locally from the miocene Humboldt Formation. The material is from mixed parent rocks among which limestone, shale, quartzite and basalt predominate.

Climate: Mean annual rainfall 12-15 inches and a mean annual temperature of 45°F. Most of the rainfall comes as snow during winter months.

Other Features: The soil profile at time of sampling was dry to approximately 30 inches. Below 30 inches the moisture content was at about 20-30% of field capacity. The ground water table is below 15 feet. A fair plant litter is present and erosion slightly active.

Soil Profile

Tulasco gravelly loam

(S56-Nev-4-3-1) A_1 0-5" Very dark gray (10YR 3/1) gravelly loam, gray (10YR 5/1) when dry. The gravel content is predominantly chert and quartzite, subangular, and up to 1 inch in size. Moderate fine to medium platy; slightly hard, friable and slightly sticky;

Many fine and few coarse fibrous roots; ph 8.6 with thymol blue (1:5); noncalcareous; clear wavy lower boundary.

(S56-Nev-4-3-2) B_2 5-14" Very dark grayish brown (10YR 3/2) clay. Moderate coarse angular blocky in place breaking to strong medium subangular blocky peds; thick continuous clay skins on vertical and horizontal ped surfaces; inside of peds are dark brown (10YR 3/3). Contains 10-15% chert and quartzite gravel up to 1 inch in size; very hard, friable, very sticky, and plastic; few to numerous fine fibrous roots; ph 8.4 with thymol blue (1:5); noncalcareous; clear wavy lower boundary.

(S56-Nev-4-3-3) B_3 14-30" Dark brown (10YR 3/3) very gravelly loamy sand. Massive in place breaking to strong fine to medium subangular blocky peds; thin clay skins on ped surfaces; contains about 60% gravel up to 2 inches in size; very hard, friable, sticky and plastic; few fine and coarse fibrous roots; ph 8.4 with thymol blue (1:5); noncalcareous; clear wavy lower boundary.

(S56-Nev-4-3-4) Cca_1 30-42" Dark grayish brown to grayish brown (10YR 4/2 to 5/2) sandy clay loam. Contains few quartzite stones 4-10 inches in diameter; massive in place breaking to weak coarse subangular blocky; very hard friable, sticky and plastic; very few fine and coarse fibrous roots; ph 8.6 with thymol blue (1:5); calcareous in spots only; clear wavy lower boundary.

(S56-Nev-4-3-5) Cca_2 42-54" Grayish brown (10YR 5/2 to 2.5Y 5/2) gravelly sandy loam and loamy sand. Contains about 25% gravel and few stones. Many fine faint white (10YR 8/1) lime mottles; massive to single grained; soft very friable and nonsticky; very few roots; ph 8.7 with thymol blue (1:5); highly calcareous; clear wavy lower boundary.

(S56-Nev-4-3-6) Cca_3 54-74"+ Grayish brown (10YR 5/2 to 2.5Y 5/2) very gravelly loamy sand. Contains 60-70% gravel and few limestone and chert stones; massive to single grained; soft, very friable and nonsticky; very few roots; ph 8.7 with thymol blue (1:5); calcareous with heavy lime coatings on under side of stones and gravels.

Remarks: This soil represents a moderate to strongly developed upland soil developed under grassland vegetative cover. It is high in organic matter and has an estimated available water holding capacity of about 5 inches.

Analysis of soil samples from the three soils sampled at the Clover Creek Station in September 1956 by E. A. Naphan, D. G. Bagley and A. T. Bleak are shown in Tables 4 , 5 and 6 . Analysis of soil samples were made at the Soil Laboratory at the Utah State Agricultural College under the supervision of Mr. James P. Thorne. Listed below is an explanation of the analysis plus a partial interpretation of these analyses which was taken from a letter written by Mr. James P. Thorne.

"There was no evidence of salt or sodium accumulation in either of the first two profiles. Somewhat high pH values were obtained in the last two horizons of the third profile. We, therefore, made the exchangeable sodium analysis and found the 42-54 inch depth had an exchangeable sodium percentage of 5, while the 54-76 inch depth had a sodium percentage of 3. It is generally assumed that a sodium percentage of around 15 is critical, or is a point where crops are adversely affected, either directly or indirectly. The total soluble salt contents of these two subsoil samples were very low and the samples did contain an appreciable amount of lime. It would appear, therefore, that there has been very little movement of water through this soil. Otherwise, one would expect this sodium to be replaced by calcium.

Values reported for sand, silt and clay were obtained with the hydrometer. This is an approximate method, but comparisons with the pipette method have shown the clay percentage is generally within plus or minus 3 percent. For example, the 2 micron clay on your first

sample is 21. A precise measurement of clay might show it to be as low as 18 or as high as 24. All of these samples contained appreciable amounts of gravel greater than 2 millimeters. The amounts greater than 2 millimeters are expressed as a percentage of the total sample. Sand, silt and clay are based on the sieve sample, so that the value for sand, silt and 2 micron clay total to 100.

pH measurements were made using the Beckman pH meter and readings were taken at two different moisture contents. The first one reported is on the saturated paste; the second is on a 1:5 suspension.

Organic matter was determined using the wet oxidation method with the heat treatment as given in Ag. Handbook #60, Method 24. Organic carbon values are also reported. The relationship between the two is: organic matter equals 1.72 x organic carbon.

Carbon nitrogen ratios seem somewhat high, particularly on sample U563255. We shall check the determinations on this sample and advise you of any deviations from the values reported.

You may note that no appreciable amount of lime was found in any of these profiles until rather deep in the subsoil.

Available phosphorus was measured using the sodium bicarbonate method of extraction proposed by Olsen, et. al. The results obtained show these three profiles to be rather well supplied with available phosphorus. It appears that the first profile, your No. 4-1, is so high in available phosphorus that no crops would respond to phosphate fertilizer. That also applies to profile 4-2, although it contains somewhat less than 4-1. Alfalfa likely would not respond to phosphate on the area represented by profile 4-3, but vegetable crops and sugar beets likely would respond to phosphate on this soil."

Table 4 .

Soil Survey Laboratory
Logan, Utah

Soil Type Clover - SS - Elko Co.
BCX44 - Lower

Sample No. S56-Nev. 4-1-1 to 4-1-10

Laboratory Number	Depth in Inches	Sample No.	Particle Size Distribution (Percent) Sand	Silt	Clay .002	Clay .005	>2	pH Saturated Paste	pH 1:5
U563245	0-3½	3-1-1	38	41	21	31	27	6.9	7.8
U563246	3½-7½	3-1-2	43	36	21	28	24	7.1	7.9
U563247	7½-17½	3-1-3	41	36	23	31	17	7.0	7.9
U563248	17½-30	3-1-4	54	26	20	24	26	7.2	8.1
U563249	30-35	3-1-5	38	41	21	28	6	7.3	8.1
U563250	35-41	3-1-6	51	29	20	25	37	7.5	8.1
U563251	41-45½	3-1-7	49	31	20	24	39	7.4	8.3
U563252	45½-60	3-1-8	32	42	26	32	22	7.8	8.6
U563253	60-67	3-1-9	38	39	23	30	18	8.0	8.6
U563254	67-80+	3-1-10	37	41	22	31	12	7.7	8.5

Organic Matter % Organic Matter	% Organic Carbon	% Nitrogen	C/N	Est. % Salt (Bureau Cup)	CaCO3 Equiv. %	Moisture Tensions 1/3 Atmos. %	15 Atmos. %	Avail. P_2O_5 lbs/a
7.77	4.52	.310	14.6	.04	.2	26.6	14.0	175
6.21	3.61	.260	13.9	<.02	.3	25.1	13.9	
4.39	2.55	.177	14.4	.02	.2	23.7	11.4	
2.27	1.32	.109	12.1	<.02	.2	16.2	9.8	
3.08	1.79	.136	13.2	.03	.2	22.4	11.4	
3.22	1.87	.139	13.4	<.02	.1	19.7	9.1	
2.68	1.56	.148	10.5	.03	.1	19.1	9.6	
4.01	2.33	.156	14.9	.04	3.1	29.2	13.6	
2.96	1.72	.138	12.4	.03	1.6	28.6	13.4	
2.01	1.17	.127	9.2	.04	.3	28.1	13.2	

Table 5 .

Soil Survey Laboratory
Logan, Utah

Soil Type Clover - SS - Elko Co.
BCXh4 - Middle

Sample No. S56 Nev. 4-2-1 to 4-2-7

Laboratory Number	Depth in Inches	Sample No.	Particle Size Distribution (Percent) Sand	Silt	Clay .002	Clay .005	>2	pH Saturated Paste	pH 1:5
U563255	0-5	3-2-1	61	23	16	21	42	6.9	7.6
U563256	5-18	3-2-2	59	24	17	22	37	7.0	7.7
U563257	18-33	3-2-3	56	23	21	24	58	7.3	7.8
U563258	33-41	3-2-4	57	23	20	23	35	7.5	8.1
U563259	41-47	3-2-5	57	23	20	24	38	7.9	8.4
U563260	47-55	3-2-6	60	20	20	25	38	7.9	8.9
U563261	55-74	3-2-7	61	20	19	23	44	8.3	8.9

Organic Matter: Organic Matter	Organic Matter: % Organic Carbon	Organic Matter: % Nitrogen	C/N	Est. % Salt (Bureau Cup.)	$CaCO_3$ Equiv. %	Moisture Tensions: 1/3 Atmos. %	Moisture Tensions: 15 Atmos. %	Avail P_2O_5 lbs/a
4.06	2.36	.140	16.8	<.02	.5	16.8	8.6	96
2.17	1.26	.111	11.3	<.02	.3	15.5	8.6	
1.65	.96	.096	10.0	<.02	.2	15.9	8.7	
1.26	.73	.084	8.7	.03	.4	14.5	8.1	
1.27	.74	.080	9.2	.03	.9	15.0	8.2	
.95	.55	.061	9.0	.03	5.5	15.9	8.0	
.69	.40	.051	7.8	.02	11.8	15.7	9.2	

Table 6 .

Soil Type Clover - SS - Elko Co. BCKl4 - Upper

Soil Survey Laboratory
Logan, Utah

Sample No. S56 Nev. 4-3-1 to 4-3-6

Laboratory Number	Depth in Inches	Sample No.	Particle Size Distribution (Percent) Sand	Silt	Clay .002	Clay .005	>2	pH Saturated Paste	pH 1:5
U563262	0-5	3-3-1	46	25	29	35	27	7.1	7.9
U563263	5-14	3-3-2	40	14	46	51	34	6.7	7.8
U563264	14-30	3-3-3	56	14	30	34	43	7.0	7.8
U563265	30-42	3-3-4	47	32	21	23	53	7.6	8.5
U563266	42-54	3-3-5	74	12	14	16	51	8.1	9.0
U563267	54-76	3-3-6	77	11	12	15	60	8.3	9.2

Organic Matter	Organic Matter % Organic Carbon	% Nitrogen	C/N	Est. % Salt (Bureau Cup)	EC x 10^3	$CaCO_3$ Equiv. %	Gypsum me./100g Soil
1.84	1.07	.089	12.0	.03		.1	
1.51	.88	.086	10.2	.05		.1	
.57	.33	.040	8.2	.05		.2	
.34	.20	.032	6.2	.03		.3	
.15	.09	.015	6.0	.02	.48	3.6	<1
.14	.08	.018	4.4	.02	.57	3.0	<1

Moisture Tensions 1/3 Atmos. %	15 Atmos. %	Avail. P_2O_5 lbs/a	Cation Exchange Capacity	Exchangeable Cations Na	Exchangeable Sodium % ESP	% Moisture At Saturation
17.3	8.6	55	-	-	-	-
27.9	20.3		-	-	-	-
20.2	13.2		-	-	-	-
13.8	8.7		-	-	-	-
10.3	5.8		27.7	1.28	5	26
9.8	5.3		25.7	.85	3	25

II-D. RANGE EVALUATION OF LEGUMES

The advantages of grass-legume mixtures for conservation work and pasture mixtures on farmland in sub-humid areas and under irrigation has long been recognized. To date, little work has been done on grass-legume mixtures for arid and semi-arid western rangelands. It is known that many of the legumes suited for irrigated land will not grow on the more arid rangelands. Additional work is needed to thoroughly test all species and varities which may be adapted to the rangelands in the western states.

Studies were started near Reno, Nevada in the fall of 1953. This area is located at an elevation of approximately 6,300 feet in Dog Valley, California. Trials are on Forest Service land administered by the Carson Ranger District, Toiyabe National Forest. The area is reached from Reno, Nevada by taking Highway 40 west to Verdi, Nevada. The Dog Valley road is then traveled until it forks at the first summit. The right hand fork leading down into the valley is followed for 0.6 mile until it crosses Dog Creek. Trial plantings have been made along Dog Creek. A livestock-rabbit exclosure was established 1.2 miles east of this crossing.

A. Clonal material of three of the Canadian spreading alfalfas were obtained from Dr. O. F. Smith, Forage and Range Section of the Agricultural Research Service on September 11, 1953. Three plants of each strain were planted 4 feet apart within a small

livestock exclosure. Supplemental water was applied at the time of planting and 7 and 14 days after planting. Strains are as follows: SC24724, SC24729, and SC24736.

Moles or pocket gophers damaged some of the plants during the winter of 1953-1954 and the spring of 1954. These plants made some growth but showed little indication to creep or spread in 1954. The three plants of SC24724 and one plant of SC24736 showed some creeping in August 1955. Two plants of SC24729 died in 1955 following gopher damage. The taproot on one of the original plants of SC24729 was severed. This killed the original plant but the surrounding sprouts remained alive.

On April 19, 1956 all plants of SC24724 and SC24736 showed some life. On July 4 heavy pocket gophers activity within the exclosure had apparently killed all plants of SC24729, two plants of SC24736 and one plant of SC24724. The plants still living on this date showed moderate spreading although gophers had damaged all plants. Due to repeated damage to the fence by deer and the damage by gophers this area was abandoned.

Many of the alfalfas and legumes have a single taproot which is easily destroyed by gophers and other rodents, thus killing the plant. These plants have exibited an ability to withstand gopher damage much better than the single taproot varieties of alfalfa. This planting has demonstrated the value of spreading alfalfas on rangelands where pocket gophers have been a serious problem.

B. Seven selected strains of creeping alfalfas were obtained from Dr. O. F. Smith on May 28, 1954. Plants were transplanted directly from flats. Plants were from 4 to 8 inches high and had a well developed root system. Top growth was cut back to approximately 2 inches and the roots were pruned as necessary.

Each strain was planted in two single row plots 20 feet long. Plants were spaced 1 foot apart along each row. Supplemental water was applied at the time of planting on May 31 and the entire area was irrigated with a sprinkler system on June 7. Superphosphate was applied to plots 101 through 107 (one replication) at a rate of 100 pounds per acre.

Plants made good growth but did not spread or creep in 1954. Moles or pocket gophers killed or damaged some of the plants in the summer of 1954. Frost heaving during the winter of 1954 or early spring of 1955 resulted in death or damage to 4 plants of P1212-133, 2 plants of P1212-136, and 1 plant of P1212-131. All dead plants except those of P1212-135 were replaced with vigorous plants on May 25, 1955.

The livestock exclosure was fenced against rabbits in the early spring of 1955. Plants made fair growth during the summer of 1955 but no spreading or creeping was apparent this year. The application of phosphates did not produce measurable differences between the two replications. Heavy deer grazing began in September and continued until late October.

Eight selected strains including six of the strains included in 2 above were transplanted directly from flats on May 25, 1955. These plants were also obtained from Dr. O. F.Smith. Top growth was cut back to approximately 2 inches and the roots were pruned as necessary. Each strain, except P1212-135, was planted in two single row plots 20 feet long. There were only eight plants of P1212-135 and all plants were placed in one row. Plants were spaced 1 foot apart. Supplemental water was applied at the time of planting and 2 weeks after planting. A plot diagram of strains planted in the spring of 1954 and 1955 are shown in the 1955 report.

Most plants made good growth and appeared thrifty on September 20, 1955. When this study was visited on April 19, 1956 a number of these accessions were showing some creeping. The number of living plants in September 1956 and degree of creeping are shown in table 7.

In the fall of 1955 lime, at a rate of 1½ tons per acre, was applied as a top dressing over the area planted in the spring of 1955. Little or no response from the application of lime was observed in 1956.

C. Fifteen alfalfa strains were planted on moistened soil on June 3, 1954. The planting was irrigated on June 7. This irrigation wet the soil to a minimum depth of 1 foot. Seed was broadcast at a rate of approximately 5 pounds per acre (three grams per row)

Table 7. Creeping alfalfa transplants made in Dog Valley, California May 28, 1954 and May 25, 1955.

Plot	Accession No.	Year planted	Degree of Spreading Sept. 29, 1956
105	PI212-131	1954	slight to moderate
203		1954	slight to moderate
405	PI212-132	1955	none
504		1955	none
101	PI212-133	1954	slight to moderate
204		1954	slight to moderate
402		1955	none
505		1955	none
103	PI212-134	1954	good to moderate
207		1954	moderate
403		1955	none
501		1955	none
107	PI212-135	1954	moderate
205		1954	moderate
408		1955	none
104	PI212-136	1954	slight
202		1954	slight
407		1955	none
502		1955	none
106	PI212-137	1954	slight
201		1954	moderate
404		1955	none
506		1955	none
102	PI212-138	1954	moderate
206		1954	moderate
406		1955	slight
507		1955	none
401	24724x24760	1955	moderate (max. of 16 ins.)
503	(Upright type)	1955	moderate (max. of 15 ins.)

and then covered with soil to a depth of 1/4 to 1/2-inch. Soil was firmed by stepping along the row. All seed was treated with nitrogen fixing bacteria.

Mortality during the winter of 1954-1955 was high. Many plants were frost heaved and some apparently were frosted and killed during the spring of the year. On May 26, 1955 plants were often clustered under some protection such as a dead sagebrush plant and these plants were larger than those in the open. Deer use on the area was very light until September. Deer are not considered to be an important factor in the high plant mortality which occurred in the winter of 1954-1955 or spring of 1955. The number of plants present in 1954, 1955, and 1956 from the direct seeding in 1954 are shown in table 8.

The three accessions from Canada SC3504, SC3513, and SC34922 were spreading by rhizome. Accession SC3513 had spread to 25 inches and 30 on the 2 plots. The other two Canadian strains had only demonstrated a weak spreading by rhizomes.

D. The same strains (accession numbers) planted on June 3, 1954 plus a strain of Medicago falcata were planted on adjacent single row plots on October 22, 1954. Planting procedures were the same except that rows were only 18 inches apart and seed was planted at a rate of 3 grams per row. Eight other legumes were also planted at this time. On May 26, 1955 most of the alfalfa seedlings from the fall of 1954 planting had been killed by frost.

Table 8 . Number of plants in 1954, 1955 and 1956 from a direct seeding of selected alfalfa strains planted on June 3, 1954 and irrigated to provide conditions favorable for seed germination.

Plot	Name and Accession No.	1954	1955		1956
		August 23	April 25	Sept. 30	Sept. 29
114	PC23982	11.5	0.15	0.05	0.05
314	Uruguay c. 10	8.3	0.20	0.20	0.15
214	PC24189	9.9	0.55	0.35	0.25
215	Ranger	11.2	0.70	0.55	0.55
109	PC24660	12.3	0.90	0.65	0.65
311	Sevelra	12.8	1.00	0.75	0.70
111	PC24798	9.4	1.15	0.70	0.70
301	Rhizoma	3.7	0.60	0.45	0.40
113	PC24864	10.8	0.15	0.10	0.05
313	Buffalo	11.9	0.25	0.25	0.15
212	PC31983	13.9	2.35	1.55	0.90
306	Vernal	5.2	0.40	0.35	0.35
209	PC32075	11.0	1.20	0.90	0.75
302	A-169	3.6	0.40	0.30	0.30
108	PC32085	9.8	1.55	0.90	0.70
303	Nomad	4.4	0.20	0.15	0.15
115	PC32129	12.3	1.80	1.05	0.15
308	A-224 Syn 3	4.6	0.55	0.40	0.40
110	PC32142	8.6	2.00	1.50	0.75
309	Ma5110	4.3	1.05	0.75	0.70
112	PC32143	5.1	1.50	1.00	0.10
307	SC3504	2.9	0.55	0.55	0.60
211	PC32144	4.0	1.50	0.95	1.2
312	SC3513	6.4	2.10	1.40	1.4
213	PC32145	7.8	1.25	1.05	0.90
305	SC34922	4.3	1.50	1.10	0.85
210	Commercial	11.0	0.50	0.45	0.35
304	Ladak	7.3	0.20	0.20	0.25
208	IFAFES Ranger x	8.4	2.70	1.65	1.00
310	M. glutinosa	10.0	1.00	0.70	0.65

On May 28 all alfalfa seedlings on this planting had been killed by frost. Some of the seedling plants from other legumes appeared to be more frost resistant. Most of the alfalfa present on this area in the summer and fall of 1955 came from seed germinating in late May and June. On October 18, 1955 all species were replanted in rows placed between the original rows planted in the fall of 1954.

On April 19, 1956 all alfalfa seedlings which had germinated prior to this time had been killed by frost, but many of the other legumes had fair seedling stands. Additional counts of all alfalfa and other legumes from the 1954 and 1955 plantings were made in September 1956. Seedling and plant counts are shown in table 9.

Table 9 . Legume seedlings and plants present in 1955 and 1956 from plantings made in the fall of 1954 and 1955.

Plot	Name or Accession No.	Year Planted	Number of plants per linear ft. of row			
			1955		1956	
			May 28	Oct. 18	April 19	Sept. 29
	Alfalfa					
101	FC32075	1954	0.00	0.20	0.20	0.20
204	A-169	1954	0.00	0.10	0.10	0.20
101A		1955			0.00	0.00
204A		1955			0.00	0.00
102	FC32143	1954	0.00	0.65	0.65	0.70
210	SC3504	1954	0.00	0.55	0.50	0.50
102A		1955			0.00	0.20
210A		1955			0.00	0.25
103	FC24660	1954	0.00	0.15	0.05	0.05
202	Sevelra	1954	0.00	0.20	0.20	0.20
103A		1955			0.00	0.10
202A		1955			0.00	0.10
104	FC32145	1954	0.00	0.20	0.20	0.25
212	SC34922	1954	0.00	0.40	0.35	0.35
104A		1955			0.00	0.40
212A		1955			0.00	0.65
105	FC32085	1954	0.00	0.35	0.35	0.35
205	Nomad	1954	0.00	0.25	0.20	0.20
105A		1955			0.00	0.25
205A		1955			0.00	0.10
106	FC24798	1954	0.00	0.35	0.35	0.40
214	Rhizoma	1954	0.00	0.20	0.20	0.30
106A		1955			0.00	0.15
214A		1955			0.00	0.80
107	FC32142	1954	0.00	0.20	0.20	0.35
213	Ma 5110	1954	0.00	0.30	0.25	0.25
107A		1955			0.00	0.15
213A		1955			0.00	0.25
108	Ranger x M.	1954	0.00	0.95	0.90	0.90
207	glutinosa	1954	0.00	1.05	0.75	0.75
108A		1955			0.00	0.25
207A		1955			0.00	0.35

Plot	Name or Accession No.	Year Planted	Number of plants per linear ft. of row 1955 May 28	1955 Oct. 18	1956 April 19	1956 Sept. 29
	Alfalfa					
109	PC32144	1954	0.00	0.60	0.50	0.45
216	SC3513	1954	0.00	0.55	0.50	0.45
109A		1955			0.00	0.10
216A		1955			0.00	0.35
110	PC24864	1954	0.00	0.00	0.00	0.00
215	Buffalo	1954	0.00	0.00	0.00	0.00
110A		1955			0.00	0.00
215A		1955			0.00	0.40
111	PC24189	1954	0.00	0.15	0.15	0.20
206	Ranger	1954	0.00	0.15	0.15	0.60
111A		1955			0.00	0.10
206A		1955			0.00	0.10
112	PC23982	1954	0.00	0.00	0.00	0.00
211	Clone #10	1954	0.00	0.00	0.00	0.00
112A		1955			0.00	0.10
211A		1955			0.00	0.00
113	Mesa 36	1954	0.00	0.10	0.10	0.15
201	Ladak	1954	0.00	0.10	0.10	0.15
113A		1955			0.00	0.15
201A		1955			0.00	0.15
114	PC32129	1954	0.00	0.15	0.10	0.10
208	A224 Syn 3	1954	0.00	0.60	0.55	0.50
114A		1955			0.00	0.15
208A		1955			0.00	0.10
115	Medicago	1954	0.00	0.45	0.40	0.40
203	falcata	1954	0.00	0.70	0.70	0.90
115A		1955			0.00	0.40
203A					0.00	0.35
116	PC31983	1954	0.00	0.05	0.05	0.10
209	Vernal	1954	0.00	0.00	0.00	0.00
116A		1955			0.00	0.15
209A		1955			0.00	0.00

Plot	Name or Accession No.	Year Planted	Number of plants per linear ft. of row			
			1955		1956	
			May 28	Oct. 18	April 19	Sept. 29
	Other Legumes					
301	Ladino	1954	0.20	0.15	0.10	0.10
309	clover	1954	0.40	0.40	0.20	0.15
301A		1955			0.00	0.05
309A					0.00	0.15
302	Lupinus	1954	0.75	0.10	0.60	0.10
313	alpestris	1954	1.85	0.70	0.85	0.25
302A		1955			0.50	0.45
313A		1955			0.65	0.30
303	Astragalus	1954	0.20	0.05	0.70	0.50
316	falcatus	1954	1.35	1.10	1.30	1.15
303A		1955			0.75	0.25
316A		1955			1.60	0.85
304	Astragalus	1954	0.40	0.25	1.20	0.95
315	cicer	1954	5.15	1.40	2.00	1.95
304A		1955			2.40	1.95
315A		1955			1.90	2.00
305	Melilotus	1954	0.00	0.00	0.00	0.00
310	officinalis	1954	0.00	0.00	0.00	0.00
305A		1955			0.00	0.00
310A		1955			0.00	0.00
306	Lupinus	1954	1.20	1.55	1.60	1.15
314	spp.	1954	2.75	2.00	2.00	2.20
306A		1955			0.40	0.65
314A		1955			0.35	0.50
307	Lathyrus	1954	0.15	0.25	0.20	0.20
312	sylvestris	1954	0.95	0.85	0.75	1.00
307A		1955			0.30	0.30
312A		1955			0.50	0.85
308	Vicia	1954	1.15	0.80	0.80	1.15
311	tenuifolia	1954	1.10	0.90	0.70	0.80
308A		1955			0.95	0.90
311A		1955			0.90	0.70

II-E. EXPLORATORY FIELD TRIAL WITH SELECTED FERTILIZERS ON ESTABLISHED CRESTED WHEATGRASS STANDS AT SWEETWATER FLAT

To date very little work has been done on the use of nitrogen or other fertilizer under dryland conditions. Dryland crop production in Nevada is almost negligible, primarily due to low precipitation. The average annual precipitation for Nevada is only about 9 inches. "Nevada Precipitation and Acreages of Land by Zones" prepared by Mr. George Hordman is presented below.

Precipitation Zone	1,000 Acres	Percentage
0-5	12,866	18.1
5-8	17,197	24.3
8-12	27,087	38.3
12-15	9,708	13.7
15-20	3,186	4.5
20 plus	798	1.1

Approximately 400,000 acres of rangeland has been seeded to crested wheatgrass. Since little or no fertility work had been done under the dryland conditions, an exploratory trial was established on a range planting of crested wheatgrass on Sweetwater Flat in the fall of 1953. This area is on a small portion of a 2,200 acre reseeding project conducted by the Toiyabe National Forest in 1950, 1951, and 1952.

The study plot was placed on a piece of land which had been leveled to provide a temporary air-strip and seeded in 1950. This area supported a uniform stand of crested wheatgrass. It was

relatively free of brush and level enough to facilitate the use of a small power mower in taking herbage yields. The soil is a loose sandy material of granitic origin. The elevation is about 7,200 feet and estimated annual precipitation is about 12 inches. Precipitation data from Sykes gages, located approximately 3/4-mile to the east, are shown in Section II-F.

This study was established in the fall of 1953 with the aid and cooperation of Dr. J. H. Robertson and is conducted in cooperation with the Nevada Agricultural Experiment Station, a contributing project to W-25. An area 70 feet wide by 140 feet long was fenced against livestock and rodents (fig. 21). Eighteen plots, each 8 feet wide by 40 feet long were staked out. Plots were divided into three blocks and the following treatments were applied at random in each block.

1. Ammonium sulfate at 30 pounds of nitrogen per acre
2. Ammonium sulfate at 90 pounds of nitrogen per acre
3. Superphosphate at 100 pounds P_2O_5 per acre
4. Nitrogen at 30 pounds per acre and P_2O_5 at 100 pounds per acre
5. Sulfur at 100 pounds per acre
6. No treatment

Mower strip yields were used to compare herbage production. Two swaths 2.5 feet wide by 37.5 feet long, or 187.5 feet were cut in each plot. Shrubs and weeds were clipped with the crested wheatgrass but were hand separated. Plant height and number of flower

Figure 21. The carry over effects from a single application of nitrogen in 1953 at 30 pounds per acre can be seen on the plot on the right. The plot on the left received P_2O_5 at a rate of 100 pounds per acre (B56-77).

stalks per plant were obtained on 10 plants selected at random within each plot and green weight samples of the crested wheatgrass herbage were obtained at the time of clipping from all plots in 1955 and 1956. Plots were clipped on July 6, 1956.

No additional fertilizer was applied in 1954, 1955, or 1956. A significant increase in herbage production occurred from the 1953 application of nitrogen at both 30 and 90 pounds per acre in 1954, 1955, and 1956. It is quite likely that this carryover of nitrogen will continue for at least one more year (1957). It has not been determined whether such increases would be economical but similar increase in 1957 would probably warrant application of nitrogen at 30 pounds per acre on similar land.

The addition of nitrogen also resulted in more flower stalks per plant in 1955 and 1956. Observations made about May 15 in 1955 and 1956 showed a greater length of leaves (height of plants) on the plots receiving nitrogen at this time but this difference was no longer apparent by the end of June in either year. The percentage of moisture in herbage at the time of clipping in 1955 and 1956 failed to show a significant difference due to application of nitrogen at the time of clipping but a significant difference was observed in 1954. It is suggested that moisture content of crested wheatgrass be determined at intervals during the 1957 growing season. Little or no response was found from the application of P_2O_5 on this study. The application of sulfur at 100 pounds per acre did not result in a

significant increase in herbage production but it may have had some beneficial effects. Data for 1954 and 1955 are presented in the reports for those years. Data for 1956 including plant height, number of flower stalks, percent dry matter, and herbage yields are shown in table 10.

Table 10. Plant heights, number of flower stalks, and herbage yield in 1956 on an established stand of crested wheatgrass treated with selected fertilizers in the fall of 1953.

Treatment[1] and Plots		Average height[2] Leaves	Average height[2] Flower stalks	Ave. No.[3] Flower stalks	% Dry Matter	Air-dry Pounds per acre Grass	Air-dry Pounds per acre Others
Check	105	5.7	12.0	10.0	53.8	240.6	118.2
	202	5.8	12.0	10.3	56.3	322.4	91.8
	306	5.1	11.6	5.2	52.1	267.2	88.0
	Total	16.6	35.6	25.5	162.2	830.2	298.0
	Mean	5.5	11.9	8.5	54.1	276.7	99.3
N-30	103	5.2	11.9	14.1	54.6	522.4	124.6
	206	5.5	12.1	10.8	56.6	499.8	122.6
	303	6.2	12.7	15.8	53.9	474.1	90.0
	Total	16.9	36.7	40.7	165.1	1496.3	337.2
	Mean	5.6	12.2	13.6	55.0	498.8	112.4
N-90	104	6.7	11.7	24.2	60.0	569.7	90.4
	201	6.0	11.2	17.7	61.5	524.6	165.0
	302	6.1	12.8	17.5	55.4	708.4	176.3
	Total	18.8	35.7	59.4	176.9	1802.7	431.7
	Mean	6.3	11.9	19.8	59.0	600.9	143.9
N-30	101	6.0	11.7	17.1	57.7	478.1	143.4
P-100	204	6.2	12.4	14.5	55.0	486.5	114.0
	305	5.8	12.8	13.6	53.8	413.2	85.2
	Total	18.0	36.9	45.2	166.5	1377.8	342.6
	Mean	6.0	12.3	15.1	55.5	459.3	114.2
P-100	106	6.0	12.2	9.1	52.7	325.7	156.0
	205	5.3	12.2	10.0	54.9	321.9	95.1
	301	5.6	13.1	5.6	55.1	342.3	106.9
	Total	16.9	37.5	24.7	162.7	989.9	358.0
	Mean	5.6	12.5	8.2	54.2	330.0	119.3
S-100	102	5.2	13.2	8.9	55.2	340.3	147.8
	203	5.8	12.3	14.1	53.2	331.9	70.9
	304	6.2	13.3	8.9	55.9	388.5	141.1
	Total	17.2	38.8	31.9	164.3	1060.7	359.8
	Mean	5.7	12.9	10.6	54.8	353.6	119.9

1/ Plots 5' x 37.5' = 232.3 plots per acre
2/ Average for 10 plants selected at random.
3/ Average number of flower stalks on 10 plants selected at random.

II-F. MACRONUTRIENTS AND MICRONUTRIENTS ON ESTABLISHED CRESTED WHEATGRASS STANDS AT SWEETWATER FLAT AND ABEL CREEK

Two additional studies with macronutrients and micronutrients were activated on established stands of crested wheatgrass in the fall of 1954. These studies are also in cooperation with the Nevada Agricultural Experiment Station -- a contributing project to W-25.

The Nevada Agricultural Experiment Station established units of 12 1-acre paddocks on these areas to study brush-grass relationships under grazing at different intensities and stages of maturity, with and without nitrogen fertilization. On the Sweetwater area 6 of the paddocks were treated with ammonium sulfate at a rate of 60 pounds of nitrogen per acre. On the Abel Creek project 6 paddocks were treated with ammonium nitrate at a rate of 60 pounds of nitrogen per acre.

These studies are located within the paddocks (exclosures) which are the ungrazed check plots in the grazing trials on established crested wheatgrass conducted by the Nevada Agricultural Experiment Station (Project 95-W-25). One-half of each ungrazed paddock was rabbit proofed but small rodents such as mice or pocket gophers have been controlled by trapping or poison.

Nitrogen, at a rate of 60 pounds of nitrogen per acre, was broadcast over half of each area as a top dressing. No nitrogen was applied on the other half of these exclosures. Each half was then divided into 3 blocks and the blocks were divided into plots 7 feet

wide by 50 feet long. Macronutrients were mixed thoroughly with 2 quarts of soil taken from the plot area and the mixture was uniformly broadcast over the plot area as a top dressing except for the superphosphate which was raked into the soil following broadcasting. Micronutrients were put on in an aqueous solution (2 gallons of water per plot).

Two 50 square feet subplots (5 feet by 10 feet) were clipped by hand in each treatment plot in 1955 and 1956. Each plot was divided and 1 subplot was located at random from each half of the plot with the beginning point 1 to 15 feet from the ends of the plot. Subplots were permanently marked with large nails and will be clipped each year. A wooden frame exactly 5 feet by 10 feet was placed over the nails and the grass within the enclosed area was clipped at a 1-inch height. In addition, grass species present, number of plants and height of leaves and flower stalks of crested wheatgrass was recorded.

1. Sweetwater Flat

This study is located on the same crested wheatgrass planting described in the exploratory fertilizer trials (fig. 22). Ten different fertilizers were applied, alone and with nitrogen. Refer to the 1954 report for plot diagrams. Precipitation this area during the 1956 growing season as obtained from Sykes gages follows:

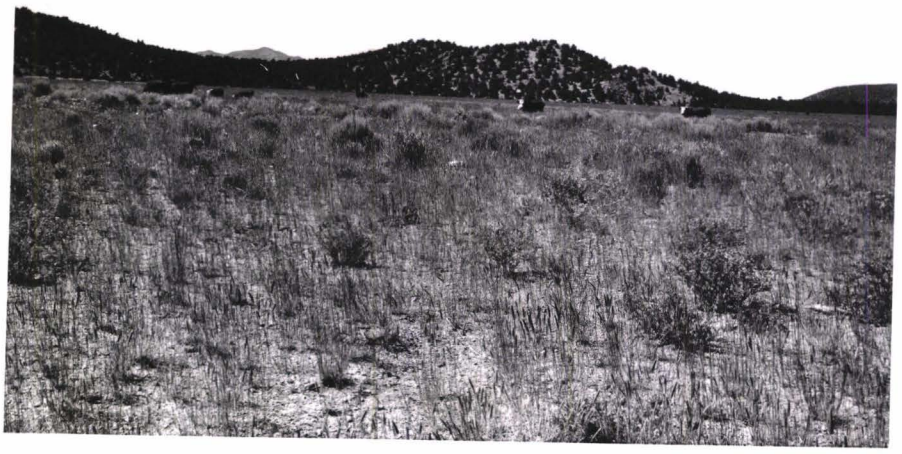


Figure 22 . Sweetwater Flat reseeding showing part of the 2,300 acres planted to crested wheatgrass. A good stand resulted but yields are low, probably due to soil fertility and low moisture holding capacity of the soil (B56-78).

Date (1956)	Precipitation (inches)
March 26	Gages put out
April 20	1.95
May 11	0.49
June 5	0.48
July 6	0.00
July 25	0.83
September 28	0.56 - Gages removed
Total - - - - - - - - -	4.31

The average air-dry yield in 1956 for all plots treated with nitrogen at 60 pounds per acre was 445.7 pounds per acre as compared to an average of 326.6 pounds on the plots not treated with nitrogen in 1954 (table 11). This increased yield from application of nitrogen will probably carry over into 1957 and 1958. Little or no response was observed when the following macronutrients or micronutrients were applied without nitrogen: phosphates, potash, sulfur, iron, copper, zinc, boron, molybdenum, magnesium, and manganese. Height of leaves and flower stalks, percent dry matter in herbage, and the average number of plants on the plots are shown in tables 12 and 13.

2. Abel Creek

This study is located near Paradise Valley, Nevada on federal range, administered by the Bureau of Land Management.

Table 11. Air-dry herbage yields in 1956 on a mature crested wheatgrass stand at Sweetwater Flat with nitrogen (60 pounds per acre) and without nitrogen plus other macronutrients or micronutrients.

Treatment - Blocks	Air-dry herbage yield (100 square feet) Nitrogen	No nitrogen	Difference
No treatment			
1 and 4	383.7	337.3	
2 and 5	402.8	405.0	
3 and 6	433.6	337.8	
Total	1220.1	1080.1	
Average	406.7	360.0	46.7
Superphosphate - 200 pounds per acre			
1 and 4	431.1	288.9	
2 and 5	423.1	378.3	
3 and 6	453.1	331.6	
Total	1307.3	998.8	
Average	435.8	332.9	102.9
Sulphate of Potash - 100 pounds per acre			
1 and 4	464.5	368.5	
2 and 5	449.8	282.1	
3 and 6	465.8	322.6	
Total	1380.1	973.2	
Average	460.0	324.4	135.6
Sulphur - 100 pounds per acre			
1 and 4	442.5	331.2	
2 and 5	451.4	355.0	
3 and 6	398.8	288.2	
Total	1292.7	974.4	
Average	430.9	324.8	106.1
Copper sulphate - 50 pounds per acre			
1 and 4	479.1	276.0	
2 and 5	423.9	373.0	
3 and 6	505.8	252.4	
Total	1408.8	901.4	
Average	469.6	300.5	169.1
Ferrous sulphate - 50 pounds per acre			
1 and 4	434.6	269.1	
2 and 5	502.7	314.6	
3 and 6	425.8	359.7	
Total	1363.1	943.4	
Average	454.4	314.5	139.9

(Continued on next page)

Treatment - Blocks	Air-dry herbage yield (100 pounds per acre) Nitrogen	No nitrogen	Difference
Magnesium sulphate - 50 pounds per acre			
1 and 4	468.2	369.9	
2 and 5	443.2	349.0	
3 and 6	465.0	300.4	
Total	1376.4	1019.3	
Average	458.8	339.8	119.0
Zinc sulphate - 50 pounds per acre			
1 and 4	478.7	304.2	
2 and 5	412.9	319.8	
3 and 6	351.5	304.6	
Total	1243.1	928.6	
Average	414.4	309.5	104.9
Sodium borate - 20 pounds per acre			
1 and 4	456.3	313.3	
2 and 5	405.6	300.5	
3 and 6	518.0	415.4	
Total	1379.9	1029.2	
Average	460.0	343.1	116.9
Ammonium molybdate - 1 pound per acre			
1 and 4	507.7	317.6	
2 and 5	432.2	260.0	
3 and 6	470.5	315.1	
Total	1410.4	892.7	
Average	470.1	297.7	172.4
Manganous sulphate - 50 pounds per acre			
1 and 4	373.2	319.8	
2 and 5	470.8	353.6	
3 and 6	482.4	362.4	
Total	1326.4	1035.8	
Average	442.1	345.3	96.8
Grand Average	445.7	326.6	119.11

Table 12. Average percent dry matter in herbage and average height of leaves and flower stalks at Sweetwater Flat on July 6, 1956.

Treatment - Blocks		Height (inches) Leaves	Stalks	Percent Dry Matter
No treatment				
Plus nitrogen	1	5.5	12.5	67.77
" "	2	6.0	12.5	67.90
" "	3	6.0	13.0	67.28
Total		17.5	38.0	202.95
Average		5.8	12.7	67.65
Without nitrogen				
" "	4	6.0	13.0	62.99
" "	5	6.0	13.0	62.48
" "	6	6.0	12.5	62.68
Total		18.0	38.5	188.15
Average		6.0	12.8	62.72
Superphosphate - 200 pounds per acre				
Plus nitrogen	1	6.0	12.0	64.58
" "	2	6.0	12.5	65.33
" "	3	6.0	12.5	66.69
Total		18.0	37.0	196.60
Average		6.0	12.3	65.53
Without nitrogen				
" "	4	6.0	14.0	62.76
" "	5	6.0	13.0	62.14
" "	6	6.0	12.0	65.58
Total		18.0	39.0	190.48
Average		6.0	13.0	63.49
Sulphate of Potash - 100 pounds per acre				
Plus nitrogen	1	6.0	13.0	67.60
" "	2	6.0	13.5	64.72
" "	3	6.0	12.0	67.68
Total		18.0	38.5	200.00
Average		6.0	12.8	66.67
Without nitrogen				
" "	4	6.0	12.0	65.10
" "	5	6.0	12.5	61.33
" "	6	6.0	13.0	62.08
Total		18.0	37.5	188.51
Average		6.0	12.5	62.84

(Continued on next page)

Treatment - Blocks		Height (inches) Leaves	Stalks	Percent Dry Matter
Sulphur - 100 pounds per acre.				
Plus nitrogen	1	6.0	12.5	67.80
" "	2	6.0	12.5	64.36
" "	3	6.0	12.5	64.06
Total		18.0	37.5	196.22
Average		6.0	12.5	65.41
Without nitrogen				
" "	4	5.5	12.5	62.20
" "	5	6.0	13.5	61.65
" "	6	6.0	12.5	63.33
Total		17.5	38.5	187.18
Average		5.8	12.8	62.39
Copper sulfate - 50 pounds per acre				
Plus nitrogen	1	6.0	12.5	65.85
" "	2	6.0	12.5	63.96
" "	3	6.0	12.5	65.80
Total		18.0	37.5	195.61
Average		6.0	12.5	65.20
Without nitrogen				
" "	4	6.0	12.5	63.64
" "	5	6.0	13.0	62.57
" "	6	6.0	12.5	62.40
Total		18.0	38.0	188.61
Average		6.0	12.7	62.87
Ferrous sulfate - 50 pounds per acre				
Plus nitrogen	1	5.5	12.5	65.95
" "	2	6.0	13.0	67.48
" "	3	6.0	12.5	66.12
Total		17.5	38.0	199.55
Average		5.8	12.7	66.52
Without nitrogen				
" "	4	6.0	12.5	63.46
" "	5	6.0	12.5	60.48
" "	6	6.0	12.5	63.71
Total		18.0	37.5	187.65
Average		6.0	12.5	62.55

(Continued on next page)

Treatment - Blocks		Height (inches) Leaves	Stalks	Percent Dry Matter
Magnesium sulfate - 50 pounds per acre				
Plus nitrogen	1	6.0	12.5	67.86
" "	2	6.0	12.0	66.28
" "	3	6.0	12.0	65.12
Total		18.0	36.5	199.26
Average		6.0	12.2	66.42
Without nitrogen				
" "	4	6.0	13.0	64.09
" "	5	6.0	12.0	62.00
" "	6	6.0	12.5	64.54
Total		18.0	37.5	190.63
Average		6.0	12.5	63.54
Maganous sulfate - 50 pounds per acre				
Plus nitrogen	1	6.0	13.0	66.77
" "	2	6.0	13.0	65.20
" "	3	6.0	12.0	65.26
Total		18.0	38.0	197.23
Average		6.0	12.7	65.74
Without nitrogen				
" "	4	6.0	12.5	63.76
" "	5	6.0	13.0	60.10
" "	6	6.0	12.5	62.96
Total		18.0	38.0	186.82
Average		6.0	12.7	62.27
Zinc sulfate - 50 pounds per acre				
Plus nitrogen	1	6.0	12.0	67.66
" "	2	6.0	12.0	64.52
" "	3	6.0	13.0	67.80
Total		18.0	37.0	199.98
Average		6.0	12.3	66.66
Without nitrogen				
" "	4	6.0	13.0	64.30
" "	5	6.0	13.0	58.37
" "	6	6.0	13.0	62.55
Total		18.0	39.0	185.22
Average		6.0	13.0	61.74

(Continued on next page)

Treatment - Blocks		Height (inches) Leaves	Stalks	Percent Dry Matter
Sodium borate - 20 pounds per acre				
Plus nitrogen	1	6.0	13.0	64.74
" "	2	6.0	12.5	66.15
" "	3	6.0	12.0	65.38
Total		18.0	37.5	196.27
Average		6.0	12.5	65.42
Without nitrogen				
" "	4	6.0	12.5	63.36
" "	5	6.0	12.5	60.80
" "	6	6.0	13.0	62.85
Total		18.0	38.0	187.01
Average		6.0	12.7	62.34
Ammonium molybdate - 1 pound per acre				
Plus nitrogen	1	6.0	12.5	66.15
" "	2	6.0	13.5	62.22
" "	3	6.0	12.0	65.12
Total		18.0	38.0	193.49
Average		6.0	12.7	64.50
Without nitrogen				
" "	4	6.0	12.5	64.61
" "	5	6.0	12.5	59.01
" "	6	6.0	12.5	62.46
Total		18.0	37.5	186.08
Average		6.0	12.5	62.03

Table 13 . Grass species on plots and average number of each per 100 square feet at Sweetwater Flat.

Treatment - Blocks	Average number of plants: Crested wheatgrass Over 1"	Crested wheatgrass 0-1"	Sitanion	Cheatgrass brome	Other
No Treatment					
Plus Nitrogen 1	87	10	8	35	1
" " 2	107	6	3	-	6
" " 3	75	10	7	-	1
Total	269	26	18	35	8
Average	89.7	8.7	6.0	11.7	2.7
Without nitrogen					
" " 4	104	4	5	-	3
" " 5	112	12	4	*	-
" " 6	85	7	6	2	5
Total	301	23	15	2	8
Average	100.3	7.7	5.0	.7	2.7
Superphosphate - 200 pounds per acre					
Plus nitrogen 1	105	2	5	-	-
" " 2	88	6	4	2	1
" " 3	108	10	5	5	2
Total	301	18	14	7	3
Average	100.3	6.0	4.7	2.3	1.0
Without nitrogen 4	118	11	7	-	8
" " 5	100	6	4	3	5
" " 6	95	3	8	-	7
Total	313	20	19	3	20
Average	104.3	6.7	6.3	1.0	6.7
Sulfate of Potash - 100 pounds per acre					
Plus nitrogen	100	5	5	29	-
" "	85	3	2	-	6
" "	123	7	4	-	9
Total	308	15	11	29	15
Average	102.7	5.0	3.7	9.7	5.0
Without nitrogen					
" " 4	118	3	8	-	-
" " 5	120	14	4	-	3
" " 6	80	5	10	5	1
Total	318	22	22	5	4
Average	106.0	7.3	7.3	1.7	1.3

(Continued on next page)

Treatment - Blocks		Average number of plants: Crested sheatgrass Over-1"	Crested sheatgrass 0-1"	Sitenion	Cheatgrass brome	Other
Sulphur - 100 pounds per acre						
Plus treatment	1	118	18	7	-	-
" "	2	110	4	4	-	5
" "	3	82	9	8	-	4
Total		310	31	19	-	9
Average		103.3	10.3	6.3	-	3.0
Without nitrogen						
" "	4	98	6	11	-	12
" "	5	76	27	5	3	2
" "	6	105	11	12	-	12
Total		279	44	28	3	26
Average		93.0	14.7	9.3	1.0	8.7
Copper sulfate - 50 pounds per acre						
Plus nitrogen	1	102	12	4	4	17
" "	2	98	3	4	-	4
" "	3	119	19	5	-	5
Total		319	34	13	4	26
Average		106.3	11.3	4.3	1.3	8.7
Without nitrogen						
" "	4	114	8	7	-	-
" "	5	123	8	6	-	5
" "	6	108	24	5	4	1
Total		345	40	19	4	6
Average		115.0	13.3	6.3	1.3	2.0
Ferrous sulfate - 50 pounds per acre						
Plus nitrogen	1	117	7	4	3	22
" "	2	101	2	5	-	5
" "	3	88	8	5	-	3
Total		296	17	14	3	30
Average		98.7	5.7	4.7	1.0	10.0
Without nitrogen						
" "	4	101	3	3	2	1
" "	5	106	5	8	2	2
" "	6	84	2	6	-	4
Total		291	10	17	4	7
Average		97.0	3.3	5.7	1.3	2.3

(Continued on next page)

Treatment - Blocks		Average number of plants: Crested wheatgrass Over-1"	Crested wheatgrass 0-1"	Sitanion	Cheatgrass brome	Other
Magnesium sulfate - 50 pounds per acre						
Plus nitrogen	1	106	3	5	-	2
" "	2	126	9	6	1	5
" "	3	129	15	10	-	9
" "	Total	361	27	21	1	16
	Average	120.3	9.0	7.0	.3	5.3
Without nitrogen						
" "	4	96	7	8	-	5
" "	5	92	7	4	-	3
" "	6	84	8	8	6	6
	Total	368	22	20	6	14
	Average	122.7	7.3	6.7	2.0	4.7
Zinc sulfate - 50 pounds per acre						
Plus nitrogen	1	110	6	4	6	-
" "	2	116	12	7	-	3
" "	3	103	3	6	-	11
	Total	323	21	17	6	14
	Average	107.7	7.0	5.7	2.0	4.7
Without nitrogen						
" "	4	91	5	3	-	12
" "	5	109	3	13	1	-
" "	6	102	7	10	-	12
	Total	302	15	26	1	24
	Average	100.7	3.0	8.7	.3	8.0
Sodium borate - 20 pounds per acre						
Plus nitrogen	1	107	8	4	-	-
" "	2	104	8	4	-	6
" "	3	122	22	6	-	5
	Total	333	38	14	-	11
	Average	111.0	12.7	4.7	-	3.7
Without nitrogen						
" "	4	104	5	2	-	-
" "	5	109	18	4	-	2
" "	6	79	3	6	-	7
	Total	292	28	12	-	9
	Average	97.3	9.3	4.0	-	3.0

(Continued on next page)

Treatment - Blocks	Average number of plants: Crested wheatgrass Over-1"	Crested wheatgrass 0-1"	Sitanion	Cheatgrass brome	Other
Ammonium molybdate - 1 pound per acre					
Plus nitrogen 1	93	2	3	-	7
" " 2	85	5	7	-	-
" " 3	101	7	3	-	8
Total	279	14	13	-	15
Average	93.0	4.7	4.3	-	5.0
Without nitrogen					
" " 4	110	6	7	-	9
" " 5	105	13	8	-	6
" " 6	101	6	5	-	11
Total	316	25	20	-	26
Average	105.3	8.3	6.7	-	8.7
Manganous sulphate - 50 pounds per acre					
Plus nitrogen 1	123	8	5	-	3
" " 2	118	19	8	-	1
" " 3	94	2	5	3	5
Total	335	29	18	3	9
Average	111.7	9.7	6.0	1.0	3.0
Without nitrogen					
" " 4	110	13	2	-	1
" " 5	119	9	4	3	-
" " 6	93	4	3	-	8
Total	322	26	9	3	9
Average	107.3	8.7	3.0	1.0	3.0

This area was cleared of brush during the spring and summer of 1952 and seeded to crested wheatgrass in the fall of 1952. The elevation is about 4,600 feet and the soil is a clay-loam. Estimated annual precipitation is about 9 inches. Precipitation on this area during the 1956 growing season as obtained from Sykes gages is shown below.

Date (1956)	Precipitation (inches)	
March 28	---	Gage put out
April 21	0.70	
May 3	0.65	
May 16	0.47	
June 6	0.84	
June 20	0.13	
November 3	1.64	Gage removed
Total -----	4.43	

Above normal precipitation occurring in January, April, and May resulted in good growth on these xeric sagebrush lands. Marked differences between the plots receiving nitrogen and those not receiving nitrogen could be seen on June 6, 1956. Plants in plots treated with nitrogen were darker in color and leafier. Some plants were in anthesis on this date. Plots were clipped on June 20, 1956.

The average air-dry yield in 1956 for all plots treated with nitrogen at 60 pounds per acre was 767.3 pounds per acre as compared to 532.7 pounds on all plots not receiving nitrogen, a

difference of 235 pounds per acre. Little or no response was observed from application of phosphates, potash, sulfur, iron, copper, zinc, molybdenum, magnesium, or boron when applied without nitrogen. Air-dry herbage, height of leaves and flower stalks, percent dry matter in herbage and number of plants per plot are shown in tables 14, 15, and 16.

Table 14. Air-dry herbage yields in 1956 on mature crested wheatgrass stands at Abel Creek with nitrogen (60 pounds per acre) and without nitrogen plus other macronutrients or micronutrients.

Treatment - Blocks	Air-dry herbage yield (100 square feet) Nitrogen	No nitrogen	Difference
No treatment			
1 and 4	900.4	659.0	
2 and 5	862.9	630.4	
3 and 6	558.3	598.4	
Total	2321.6	1887.8	
Average	773.8	629.3	144.5
Superphosphate - 200 pounds per acre			
1 and 4	1045.8	467.8	
2 and 5	1111.2	492.6	
3 and 6	424.2	470.8	
Total	2581.2	1431.2	
Average	860.4	477.1	384.3
Sulphate of Potash - 100 pounds per acre			
1 and 4	995.2	631.3	
2 and 5	825.2	612.0	
3 and 6	379.6	411.4	
Total	2200.0	1654.7	
Average	733.3	551.6	181.7
Sulphur - 100 pounds per acre			
1 and 4	961.0	560.2	
2 and 5	744.2	540.6	
3 and 6	414.2	383.4	
Total	2119.4	1484.2	
Average	706.5	494.7	211.8
Copper sulphate - 50 pounds per acre			
1 and 4	914.4	573.3	
2 and 5	872.9	597.0	
3 and 6	611.1	538.4	
Total	2398.4	1708.7	
Average	799.5	569.6	229.9
Ferrous sulphate - 50 pounds per acre			
1 and 4	685.8	742.6	
2 and 5	907.2	469.9	
3 and6	514.7	437.0	
Total	2107.7	1649.5	
Average	702.6	549.8	152.8

(Continued on next page)

Treatment - Blocks	Air-day herbage yield (100 square feet) Nitrogen	No nitrogen	Difference
Magnesium sulfate - 50 pounds per acre			
1 and 4	720.7	639.5	
2 and 5	704.6	477.6	
3 and 6	663.7	470.8	
Total	2089.0	1587.9	
Average	696.3	529.3	166.0
Zinc sulphate - 50 pounds per acre			
1 and 4	811.9	628.2	
2 and 5	828.4	685.4	
3 and 6	684.6	315.2	
Total	2324.9	1628.8	
Average	775.0	542.9	232.1
Sodium borate - 20 pounds per acre			
1 and 4	1035.6	658.5	
2 and 5	639.4	492.5	
3 and 6	929.2	360.8	
Total	2604.2	1511.8	
Average	868.1	504.0	364.1
Ammonium molybdate - 1 pound per acre			
1 and 4	953.6	592.7	
2 and 5	751.4	458.7	
3 and 6	567.5	385.2	
Total	2272.5	1436.6	
Average	757.5	478.9	278.6
Grand Average	767.3	532.7	234.6

Table 15 . Average percent dry matter in herbage and average height of leaves and flower stalks at Abel Creek in June 20, 1956.

Treatment - Blocks		Height (inches) Leaves	Stalks	Percent Dry Matter
No treatment				
Plus nitrogen	1	9.0	19.5	47.26
" "	2	10.0	21.5	48.23
" "	3	10.0	21.0	50.74
	Total	29.0	62.0	146.23
	Average	9.7	20.7	48.74
Without nitrogen				
" "	4	10.0	18.5	49.02
" "	5	9.5	23.0	46.25
" "	6	10.0	22.0	46.06
	Total	29.5	63.5	141.33
	Average	9.8	21.2	47.11
Superphosphate - 200 pounds per acre				
Plus nitrogen	1	9.0	20.5	46.15
" "	2	10.0	22.0	48.35
" "	3	10.0	20.5	47.05
	Total	29.0	63.0	141.55
	Average	9.7	21.0	47.18
Without nitrogen				
" "	4	9.5	19.0	45.84
" "	5	10.0	21.0	44.12
" "	6	10.0	21.0	47.63
	Total	29.5	61.0	137.59
	Average	9.8	20.3	45.86
Sulphate of Potash - 100 pounds per acre				
Plus nitrogen	1	9.0	18.5	46.15
" "	2	10.0	22.5	48.09
" "	3	9.0	20.0	50.35
	Total	28.0	61.0	144.59
	Average	9.3	20.3	48.20
Without nitrogen				
" "	4	9.5	20.5	47.02
" "	5	8.5	18.0	47.71
" "	6	10.0	21.0	46.42
	Total	28.0	59.5	141.15
	Average	9.3	19.8	47.05

(Continued on next page)

Treatment - Blocks		Height (inches) Leaves	Stalks	Percent Dry Matter
Sulphur - 100 pounds per acre				
Plus nitrogen	1	9.0	17.0	45.85
" "	2	10.0	21.0	47.73
" "	3	9.5	20.5	48.85
	Total	28.5	58.5	142.43
	Average	9.5	19.5	47.48
Without nitrogen				
" "	4	8.5	17.0	48.08
" "	5	9.5	21.0	46.18
" "	6	10.0	21.5	47.68
	Total	28.0	59.5	141.94
	Average	9.3	19.8	47.31
Copper sulphate - 50 pounds per acre				
Plus nitrogen	1	9.5	21.5	49.09
" "	2	10.0	23.0	47.16
" "	3	10.0	20.5	48.56
	Total	29.5	65.0	144.81
	Average	9.8	21.7	48.27
Without nitrogen				
" "	4	9.0	17.5	47.39
" "	5	9.0	19.5	47.48
" "	6	9.5	20.5	45.52
	Total	27.5	57.5	140.39
	Average	9.2	19.2	46.80
Ferrous sulphate - 50 pounds per acre				
Plus nitrogen	1	9.0	19.5	49.89
" "	2	9.5	22.0	47.72
" "	3	9.5	19.5	51.69
	Total	28.0	61.0	149.30
	Average	9.3	20.3	49.77
Without nitrogen				
" "	4	9.0	18.0	49.58
" "	5	9.5	19.0	45.53
" "	6	9.5	20.0	45.92
	Total	28.0	57.0	141.03
	Average	9.3	19.0	47.01

(Continued on next page)

Treatment - Blocks	Height (inches) Leaves	Stalks	Percent Dry Matter
Magnesium sulphate - 50 pounds per acre			
Plus nitrogen 1	9.0	21.5	48.73
" " 2	10.0	20.5	45.66
" " 3	10.0	21.5	45.25
Total	29.0	63.5	139.64
Average	9.7	21.2	46.55
Without nitrogen			
" " 4	9.0	18.5	49.96
" " 5	9.5	18.0	45.97
" " 6	9.5	19.5	48.04
Total	28.0	56.0	143.97
Average	9.3	18.7	48.00
Zinc sulphate - 50 pounds per acre			
Plus nitrogen 1	9.0	20.0	49.96
" " 2	9.5	22.0	47.72
" " 3	9.5	21.0	44.57
Total	28.0	63.0	142.25
Average	9.3	21.0	47.42
Without nitrogen			
" " 4	9.5	20.0	46.75
" " 5	9.5	20.0	47.16
" " 6	9.0	18.5	47.74
Total	28.0	58.5	141.65
Average	9.3	19.5	47.22
Sodium borate - 20 pounds per acre			
Plus nitrogen 1	9.5	20.5	47.53
" " 2	10.0	21.5	48.14
" " 3	10.0	22.0	46.34
Total	29.5	64.0	142.01
Average	9.8	21.3	47.34
Without nitrogen			
" " 4	10.0	20.0	47.49
" " 5	9.5	20.5	44.90
" " 6	9.5	20.0	46.80
Total	29.0	60.5	139.19
Average	9.7	20.2	46.40

(Continued on next page)

Treatment - Blocks		Height (inches(Leaves	Stalks	Percent Dry Matter
Ammonium molybdate - 1 pound per acre				
Plus nitrogen	1	9.5	21.0	49.37
" "	2	10.0	21.5	52.66
" "	3	9.5	20.0	52.82
	Total	29.0	62.5	154.85
	Average	9.7	20.8	51.62
Without nitrogen				
" "	4	9.0	17.0	46.11
" "	5	10.0	20.5	43.98
" "	6	9.5	20.5	48.22
	Total	28.5	58.0	138.31
	Average	9.5	19.3	46.10

Table 16. Species on plots and average number of each per 100 square feet on Abel Creek fertility flats.

Treatment - Blocks		Average number of plants: Crested wheatgrass Over 1"	Crested wheatgrass 0-1"	Sitanion	Cheatgrass brome	Other
No Treatment						
Plus nitrogen	1	82	13	7	-	-
" "	2	68	14	6	4	-
" "	3	48	57	4	127	-
Total		198	84	17	131	-
Average		66.0	28.0	5.7	43.7	-
Without nitrogen						
" "	4	128	24	4	2	-
" "	5	55	24	6	61	-
" "	6	51	51	6	4	-
Total		234	99	16	67	-
Average		78.0	33.0	5.3	22.3	-
Superphosphate - 200 pounds per acre						
Plus nitrogen	1	102	28	5	10	-
" "	2	76	16	11	-	-
" "	3	54	38	7	27	3
Total		232	82	23	37	3
Average		77.3	27.3	7.7	12.3	1.0
Without nitrogen						
" "	4	59	23	6	7	-
" "	5	46	36	3	44	-
" "	6	54	48	12	9	3
Total		159	107	21	60	3
Average		53.0	35.7	7.0	20.0	1.0
Sulfate of Potash - 100 pounds per acre						
Plus nitrogen	1	114	18	4	6	-
" "	2	57	26	4	3	-
" "	3	47	49	5	200	2
Total		218	93	13	209	2
Average		72.7	31.0	4.3	69.7	.7
Without nitrogen						
" "	4	64	12	9	7	2
" "	5	63	27	10	18	2
" "	6	43	45	10	11	-
Total		170	84	29	36	4
Average		56.7	28.0	9.6	12.0	1.3

(Continued on next page)

Treatment - Blocks		Average number of plants: Crested wheatgrass Over 1"	Crested wheatgrass 0-1"	Sitanion	Cheatgrass brome	Other
Sulphur - 100 pounds per acre						
Plus nitrogen	1	125	24	7	-	-
" "	2	77	21	12	-	-
" "	3	43	40	9	25	3
	Total	245	85	28	25	3
	Average	81.7	28.3	9.3	8.3	1.0
Without nitrogen						
" "	4	94	23	6	6	-
" "	5	47	34	21	107	3
" "	6	38	47	11	74	3
	Total	179	104	38	187	6
	Average	59.7	34.7	12.7	62.3	2.0
Copper sulfate - 50 pounds per acre						
Plus nitrogen	1	93	10	4	-	-
" "	2	52	29	5	14	7
" "	3	54	37	5	30	-
	Total	199	76	14	44	7
	Average	66.3	25.3	4.7	14.7	2.3
Without nitrogen						
" "	4	113	18	4	20	-
" "	5	45	18	17	23	-
" "	6	54	41	7	6	-
	Total	212	77	28	49	-
	Average	70.7	25.7	9.3	16.3	-
Ferrous Sulphate - 50 pounds per acre						
Plus nitrogen	1	102	13	6	7	-
" "	2	73	20	8	10	-
" "	3	44	46	6	50	2
	Total	219	79	20	67	2
	Average	73.0	26.3	6.7	22.3	.7
Without nitrogen						
" "	4	132	20	6	6	-
" "	5	45	35	17	29	-
" "	6	56	58	7	74	2
	Total	233	113	30	109	2
	Average	77.7	37.7	10.0	36.3	.7

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Treatment- Blocks	Average number of plants				
	Crested wheatgrass		Sitanion	Cheatgrass brome	Other
	Over 1"	0-1"			
Magnesium sulfate - 50 pounds per acre					
Plus nitrogen 1	73	32	4	2	1
" " 2	57	22	4	6	-
" " 3	53	28	6	65	-
Total	183	82	14	73	1
Average	61.0	27.3	4.7	24.3	.3
Without nitrogen					
" " 4	110	33	4	6	1
" " 5	38	59	21	23	2
" " 6	38	54	12	64	2
Total	186	146	37	93	5
Average	62.0	48.7	12.3	31.0	1.7
Zinc sulfate - 50 pounds per acre					
Plus nitrogen 1	90	16	9	-	2
" " 2	77	21	7	-	-
" " 3	54	19	10	8	1
Total	221	56	26	8	3
Average	73.7	18.7	8.7	2.7	1.0
Without nitrogen					
" " 4	71	20	4	6	1
" " 5	68	16	11	11	-
" " 6	40	45	10	45	2
Total	179	81	25	62	3
Average	59.7	27.0	8.3	20.7	1.0
Sodium borate - 20 pounds per acre					
Plus nitrogen 1	126	34	5	5	3
" " 2	44	32	16	40	-
" " 3	62	46	8	9	8
Total	232	112	29	54	11
Average	77.3	37.3	9.7	18.0	3.7
Without nitrogen					
" " 4	60	30	9	10	-
" " 5	47	51	2	23	-
" " 6	47	40	6	124	5
Total	154	121	17	157	5
Average	51.3	40.3	5.7	52.3	1.7

(Continued on next page)

Treatment - Blocks	Average number of plants: Crested wheatgrass		Sitanion	Cheatgrass brome	Other
	Over 1"	0-1"			
Ammonium molybdate - 1 pound per acre					
Plus nitrogen 1	83	22	4	2	-
" " 2	64	18	11	6	3
" " 3	40	42	13	4	3
Total	187	82	28	12	6
Average	62.3	27.3	9.3	4.0	2.0
Without nitrogen					
" " 4	94	31	6	5	-
" " 5	41	33	7	44	-
" " 6	45	75	3	11	-
Total	180	139	16	60	-
Average	60.0	46.3	5.3	20.0	-

III. FC-c93: ESTABLISHMENT PRACTICES FOR REVEGETATION OF RANGE AREAS IN THE WEST

Suitable establishment practices are necessary for consistently successful and effective revegetation of depleted ranges and watersheds on which the present plant cover is not adequate for soil protection or is of low forage values. The upper Colorado River Basin development provides for rehabilitation of watershed and rangelands. This expanding reseeding program is moving work into the extremes of climate and soils on which little is known about reseeding. This magnifies the importance of "know-how" in restoring the vegetation cover. Low precipitation, dry summers, sandy soil, acid soil, steep slopes and rough terrain are some of the factors which require special consideration. The range is one of the major natural resources in the Intermountain region and the people inhabiting this area are largely dependent upon the watersheds for their existence.

III-A. ESTABLISHMENT PRACTICES AND POT FERTILITY TESTS ON SOILS IN WESTERN NEVADA

Artificial revegetation of rangelands in the western portion of Nevada with grass and forbs have usually not been encouraging. Good stands have been produced at intermediate elevations on Sweetwater Flat, and on other areas on the East and West Walker Ranger

Districts within the Toiyabe National Forest. At other locations use of selected species and approved methods have usually resulted in good germination of seeds. However, these seedlings usually lacked vigor and made little growth. On two areas, 3-year old grass stands still appeared to be seedlings and herbage production was usually less than 100 pounds per acre.

Pot fertility trials were used to provide a rapid evaluation of environmental conditions on these harsh sites and problem areas. This test has been used to determine if various macronutrients or micronutrients are deficient. It has been used to evaluate the ability of soils to support alfalfa, other legumes, grasses, or special use plants. It has also been used to assist in planning field trials or to determine species and methods to be used on large plantings on private or federal rangeland. This method also has the advantage that it can be conducted during the winter months, providing greenhouse space is available. If greenhouse space is not available, it can be used in coldframes, slat houses or in the open, providing conditions are favorable for plant growth.

Pot fertility trials were conducted on six soils obtained from selected areas in eastern California, western Nevada, and from one area in north central Nevada. The soils in eastern California and western Nevada were from the east face of the Sierra-Nevada range. These soils are usually from igneous material,

usually granite or andesite. One of the better cultivated soils from western Nevada was included as a check for comparison with the other soils. The location of the areas and a brief description of these soils are listed below.

Abel Creek Seeding. This area is located in Paradise Valley, in Humboldt County, in north central Nevada. Soil was taken from within a large crested wheatgrass planting of approximately 5,000 acres. The area is part of an alluvial fan and parent material was basalt, granite, and mixed sedimentary material. Estimated annual precipitation is 9 inches and the elevation is about 4,600 feet. Native vegetation consisted primarily of big sagebrush with scattered plants of horsebrush and rabbitbrush. Fair to good crested wheatgrass stands have been established on this area.

Border Ruffian. This area is located on the headwaters of the North Fork of the Carson River in eastern California. The soil is a shallow sandy loam derived from igneous material. Native vegetation consists largely of lodgepole pine, fir, sagebrush, grasses, and mixed forbs such as onions and other ephemerals. A species trial planting on this area has produced good seedling stands but plant establishment has been very low and established plants have made little growth. The estimated annual precipitation is about 25 inches and the elevation is about 8,000 feet.

Dog Valley is located about 12 miles west of Reno, Nevada, in eastern California. The soil is derived from igneous material, primarily granite or andesite. Administration plantings and

species trial plantings in these areas have been only moderately successful. Good seedling stands have been produced on trial plantings made in the fall of 1951, 1953, 1954, and 1955. Plant establishment has been fair to good for a few species but poor for most species. Plant growth has been very slow for all species. Two year-old plants often appear to be seedlings. Native vegetation was Jeffrey pine, snowbush, manzanita, sagebrush, mixed forbs, and grasses. Elevation is about 6,300 and estimated annual precipitation is 15 inches.

Smith Valley. This soil was obtained from the Dave Soderstrom farm in Smith Valley, Nevada by Mr. Lou Langren, Soil Conservation Service, Reno, Nevada on May 4, 1956. This soil supported a native stand of sagebrush in 1949 but has been cropped for the past 7 years. No supplemental barnyard manure or commercial fertilizer had been applied to this soil. This is considered to be one of the highest producing soils to be found along the east face of the Sierra-Nevada range. Yields on similar land in Smith Valley has been about 1 ton of barley or wheat when planted at 60 pounds per acre as a nurse crop. Established alfalfa stands have yielded about 3 tons of hay per cutting, with an average yield of 5 to 6 tons of hay per year for the full life of the stand.

Sweetwater Flat is located in western Nevada, about 20 miles south of Wellington, Nevada and 20 miles north of Bridgeport, California. The soil is a loose sandy material of granitic origin.

The elevation is about 7,200 feet and estimated annual precipitation is about 12 inches. This area is on a small portion of a 2,300 acre reseeding project conducted by the Toiyabe National Forest in 1950, 1951, and 1952. The area supports a uniform stand of crested wheatgrass, but yields of forage are lower than normally expected for this elevation and precipitation. Native vegetation, prior to seeding, was made up primarily of big sagebrush, rabbitbrush, and desert peach, with a sparse grass understory. Sitanion, wheatgrass, and Stipa were the most abundant grasses. This area is surrounded by a heavy stand of Pinus monophylla and juniper.

Galena Creek. This area is located southwest of Reno, Nevada in the vicinity of Mt. Rose. Soil is a loose sandy soil from decomposed andesite and granite. This area is part of a rehabilitation project being conducted by the Toiyabe National Forest on the Carson Ranger District. The area has been severely depleted by heavy sheep use and few grasses or forbs can be seen. Clumps of whitebark and lodgepole pine occur throughout the area. A high intensity summer storm on an area in July of 1952 resulted in severe damage to the campgrounds and ranches. A similar flood from the lower portion of this area occurred in July of 1956.

Soil tests with the Lamatte Combination Soil Testing Outfit are shown in the 1956 report for all soils except the one from Smith Valley. These tests indicate that the soils from the east face of the Sierra-Nevada range are low in nitrogen. The amounts

of free aluminum present in the soils from Galena Creek and perhaps Border Ruffian study areas may indicate a toxic condition for species planted. Additional samples have been tested with a pH meter. The pH for the soils included in this test are shown below.

Location	pH
Abel Creek	7.6
Border Ruffian	5.4
Dog Valley	6.4
Galena Creek	5.9
Sweetwater	6.2
Smith Valley	6.7

Greenhouse space was not available in the Reno area and tests were conducted in coldframes during the spring. Windbreaks were made to reduce the velocity of winds and canvas covers that could be put over the frames were made to protect the plants from severe late spring frosts.

Some of the procedures used were adapted from those described by H. Jenny, J. Vlamis, and W. E. Martin in "Greenhouse Assay of Fertility of California Soils." Hilgardia, Volume 20, Number 1, May 1950. Suggestions by Dr. Wesley Keller on methods of watering and use of a cultivated soil for comparison with wildland soils were incorporated into procedures.

Trials were conducted on each soil with both Frontier barley and Romaine lettuce. These plants were used because they grow rapidly and are relatively free from disease. The lettuce should

provide an indication of how forbs will perform on each soil and the barley should provide an indication of how common grasses will perform.

Barley and lettuce plants were grown in 6-inch flower pots coated inside and outside with two layers of clear plastic. For each test pots were filled with 1,600 grams of dry soil to which the various nutrients had been added. Tests on the Abel Creek soil were made with two replications, but all other tests were made with three replications.

Ten different treatments were included in these tests. These tests are as follows: No treatment; lime; micronutrients; manure; nitrogen, phosphates, and potash; nitrogen, phosphates, potash and lime; nitrogen, phosphates, potash, lime and micronutrients; nitrogen and phosphates; nitrogen and potash; and phosphates and potash.

Lime was added as hydroxide of lime at a rate of 2 tons per acre. Processed steer manure was added at a rate of 5 tons per acre. Nitrogen was added as ammonium nitrate, at a rate of 200 pounds of N per acre; phosphorus was added as monocalcium phosphate, at a rate of 300 pounds of P_2O_5 per acre; and potassium was added as potassium sulfate, at a rate of 100 pounds of K_2O per acre. In addition, eight different chemicals were mixed together and included in this study to determine if a response to this mass application of

micronutrients would be produced. If a response had been observed, an additional test to determine the elements producing the response could be made. The following chemicals and rates per acre were used to supply these micronutrients.

Element	Chemical	Rate per acre
Boron	Sodium borate	20 pounds
Copper	Copper sulfate	50 pounds
Iron	Ferrous sulfate	50 pounds
Magnesium	Magnesium sulfate	50 pounds
Manganese	Manganous sulfate	50 pounds
Molybdenum	Ammonium molybdate	1 pound
Sulfur	Sulfur	100 pounds
Zinc	Zinc sulfate	50 pounds

Lime and manure were thoroughly mixed with dry soil. All other chemicals or mixtures of chemicals were dissolved in water and the aqueous solution was thoroughly mixed with the soil.

On May 14, 1956 five presoaked barley seeds which were beginning to sprout or a single plant of lettuce was transplanted into pots. Lettuce plants were approximately 1 month old on this date. Care was taken to wash all soil from the roots of lettuce plants before transplanting into pots. On May 25, all lettuce plants were living and all weak barley plants were replaced with healthy transplants of the same age so that one-half of all pots contained

five barley plants and one-half of the pots contained one lettuce plant. All plots were sprayed every 5 to 7 days with malathion mixed as directed for mites and aphids. All pots in a replication for each soil were kept together within the coldframe but the position of each replication was changed each week.

Watering was very carefully done to make certain that no excess water was allowed to leach out the nutrients. During the first 3 weeks selected pots were weighed to determine how much water would be needed to bring the moisture content up to approximately "field capacity" for each soil. After this time all pots were weighed each day and sufficient water was added to bring the soil moisture content to approximate "field capacity." This was determined by measuring the amount of water each 1,600 grams of air-dry soil would hold when it was allowed to drain freely. Some adjustment of total weight of pot and plants was necessary as the plants grew. This could be accurately accomplished by determining the weight of pot, soil, and plant after excessive water drained out of the pot. Excess water was caught and this water along with any leached chemicals were used in the following irrigation of the respective pots.

On July 16, 1956, 63 days after planting, photographs of 1 replication of all treatments for each soil was taken and on July 16 and 17 all lettuce and barley plants were cut at the soil surface and placed in paper sacks. Oven dry weights were made on all plants on September 14, 1956 (tables 17 and 18).

Table 17. Average height and dry herbage produced by Romaine lettuce grown in pots containing soil from 6 locations which received ten different treatments.

Treatment [3]	Smith Valley [1]	Galena Creek [1]	Dog Valley [1]	Sweet-Water [1]	Border Ruffian [1]	Abel Creek [2]
Check - $N_0P_0K_0$						
Weight (gms.)	3.94	.02	2.79	1.20	.43	2.08
Height (ins.)	4.8	.7	3.5	3.3	2.2	4.1
$N_0P_0K_0$ plus lime [4]						
Weight (gms.)	4.31	.03	2.50	2.21	2.43	2.83
Height (ins.)	5.0	.7	3.5	3.8	3.7	4.0
$N_0P_0K_0$ plus micronutrients [5]						
Weight (gms.)	4.19	.04	2.80	1.16	1.12	2.05
Height (ins.)	5.3	.9	4.2	3.4	3.00	4.2
$N_0P_0K_0$ plus manure [6]						
Weight (gms.)	3.53	.06	1.30	1.54	.42	2.24
Height (ins.)	4.15	1.1	3.0	3.8	2.5	4.6
Nitrogen, phosphates and potash - $N_2P_3K_1$						
Weight (gms.)	11.72	.02	11.93	6.64	.75	6.62
Height (ins.)	6.2	.7	5.2	4.8	2.9	5.0
Nitrogen, phosphates and potash - $N_2P_3K_1$ plus lime [4]						
Weight (gms.)	10.12	.32	11.65	6.23	7.17	4.70
Height (ins.)	5.5	2.2	5.0	5.0	5.5	5.2
Nitrogen, phosphates and potash - $N_2P_3K_1$ plus lime [4] plus micronutrients [5]						
Weight (gms.)	10.56	.45	10.67	7.29	6.85	6.28
Height (ins.)	5.7	2.3	5.4	4.9	5.0	5.0
Nitrogen and phosphates - $N_2P_3K_0$						
Weight (gms.)	11.96	.03	12.66	6.28	.78	8.95
Height (ins.)	5.8	.7	5.3	4.5	3.2	5.5

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Nitrogen and potash - $N_2P_0K_1$						
Weight (gms.)	5.94	.02	8.18	5.16	.23	4.03
Height (ins.)	5.7	.6	5.2	4.5	1.8	4.1
Phosphates and potash - $N_0P_3K_1$						
Weight (gms.)	4.69	.06	3.52	1.56	1.02	1.00
Height (ins.)	5.3	1.5	3.5	3.5	3.6	4.5
Average Dry Weight (grams)	7.10	0.10	6.80	3.93	2.1	4.08
Average Height (inches)	5.4	1.1	4.4	4.2	3.3	4.6

1/ Average for 3 replications

2/ Average for 2 replications

3/ The subscript numbers following the nutrient symbols indicate the number of units as follows: N_2 = 200 pounds of nitrogen per acre, P_3 = 300 pounds of P_2O_5 per acre, & K_1 = 100 pounds of K_2O per acre.

4/ Lime was applied at a rate of 2 tons per acre.

5/ Micronutrients added were zinc, iron, copper, magnesium, manganese, sulphur, boron, and molybdenum.

6/ Manure was applied at a rate of 5 tons per acre.

Table 18. Average height and dry herbage production by Frontier barley grown in pots containing soil from 6 locations which received ten different treatments.

	Smith Valley [1]	Galena Creek [1]	Dog Valley [1]	Sweet-water [1]	Border Ruffian [1]	Abel Creek [2]
Check - $N_0P_0K_0$						
Weight (gms.)	3.54	0.47	3.19	1.44	2.28	4.06
Height (ins.)	12.7	7.00	13.7	11.7	12.3	15.5
$N_0P_0K_0$ plus lime [4]						
Weight (gms.)	4.80	1.95	2.94	2.43	3.42	4.05
Height (ins.)	14.7	12.7	13.7	13.7	14.3	15.0
$N_0P_0K_0$ plus micronutrients [5]						
Weight (gms.)	4.82	0.49	3.64	1.84	3.84	3.17
Height (ins.)	14.7	7.7	15.0	12.0	15.0	12.5
$N_0P_0K_0$ plus manure [6]						
Weight (gms.)	4.29	1.45	2.21	1.44	3.16	4.48
Height (ins.)	14.7	12.0	12.3	11.7	14.0	13.5
Nitrogen, phosphates and potash - $N_2P_3K_1$						
Weight (gms.)	7.80	1.33	9.54	6.45	9.15	9.46
Height (ins.)	14.7	11.7	19.3	16.7	19.3	17.5
Nitrogen, phosphates and potash - $N_2P_3K_1$ plus lime [4]						
Weight (gms.)	8.68	6.08	13.29	6.47	13.21	10.22
Height (ins.)	16.0	17.0	18.7	17.7	19.3	16.5
Nitrogen, phosphates and potash - $N_2P_3K_1$ plus lime [4] plus micronutrients [5]						
Weight (gms.)	8.80	8.70	12.97	8.20	12.85	11.05
Height (ins.)	15.3	19.7	18.0	18.3	19.7	15.5
Nitrogen and phosphates - $N_2P_3K_0$						
Weight (gms.)	8.11	1.29	10.07	6.00	9.88	10.41
Height (ins.)	15.0	11.0	15.7	18.3	18.7	18.5
Nitrogen and potash - $N_2P_0K_1$						
Weight (gms.)	6.82	0.51	9.94	6.42	9.25	10.49
Height (ins.)	15.0	6.3	18.0	17.7	20.0	19.0
Phosphates and potash - $N_0P_3K_1$						
Weight (gms.)	4.30	0.80	3.46	1.33	3.26	3.25
Height (ins.)	13.3	9.7	14.0	11.0	14.0	16.0

(Continued on next page)

Average Dry Weight(Grams)	6.17	2.3	7.12	4.20	7.03	7.06
Average Height (inches)	14.6	11.5	15.8	14.9	16.7	15.9

1/ Average for 3 replications

2/ Average for 2 replications

3/ The subscript numbers following the nutrient symbols indicate the number of units as follows: N_2 = 200 pounds of nitrogen per acre, P_3 = 300 pounds of P_2O_5 per acre, + K_1 = 100 pounds of K_2O per acre.

4/ Lime was applied at a rate of 2 tons per acre.

5/ Micronutrients added were zinc, iron, copper, magnesium, manganese, sulphur, boron, and molybdenum.

6/ Manure was applied at a rate of 5 tons per acre.

As mentioned above, the high producing cultivated soil from Smith Valley was included in this test for comparison with the wildland soils. Both lettuce and barley showed some response to the application of nitrogen (figs. 23 and 24). On this soil the response to application of phosphates was less than for nitrogen but still quite marked on the pots growing lettuce. In general, the response from the addition of macronutrients, micronutrients, and soil amendments on the Smith Valley soil was less than expected considering the relatively high rate of herbage production from the small quantity of soil.

On the Galena Creek soil, barley plants showed the best response to the combined application of nitrogen, phosphate, lime, and micronutrients (figs. 26 and 28). However, a good response was obtained with barley where the combination of nitrogen, phosphates, and lime was applied but a sharp decline was noted when one of the macronutrients or the soil amendment was omitted. The addition of lime alone produced a notable increase. Phosphates alone produced some response but no benefit could be seen from the addition of nitrogen alone. Where lettuce plants were grown on the Galena Creek soil the relative response to the combined addition of lime, phosphates, and nitrogen and also the relatively response from addition of micronutrient with this combination were similar to those reported for the barley (figs. 25 and 27). However, the combined application of lime, phosphates, nitrogen, and micronutrients resulted in a total average dry weight of only 0.45 grams per pot for this

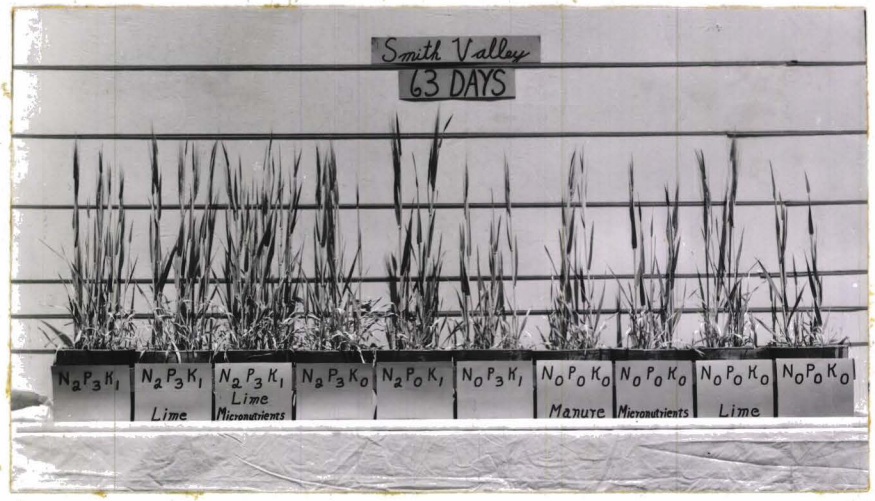


Figure [23] and [24] . Growth of Romaine lettuce and Frontier barley on soil from Smith Valley, a fertile valley soil, which was used as a check or control for comparison with soils of undetermined productivity.

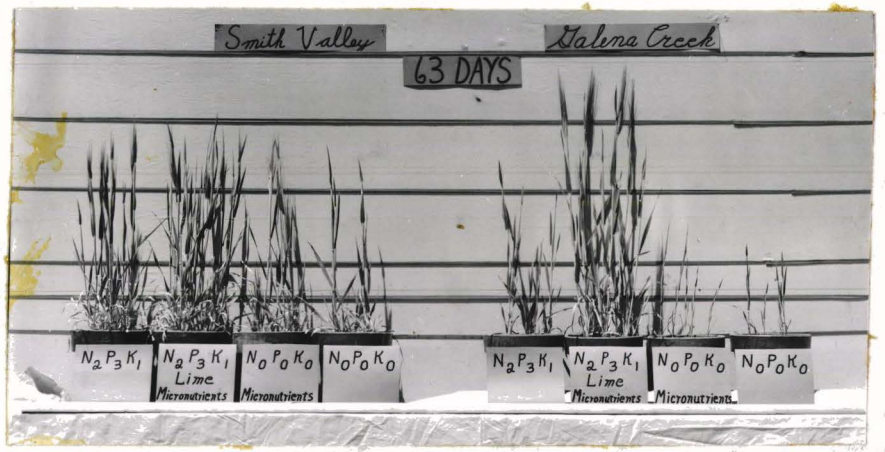
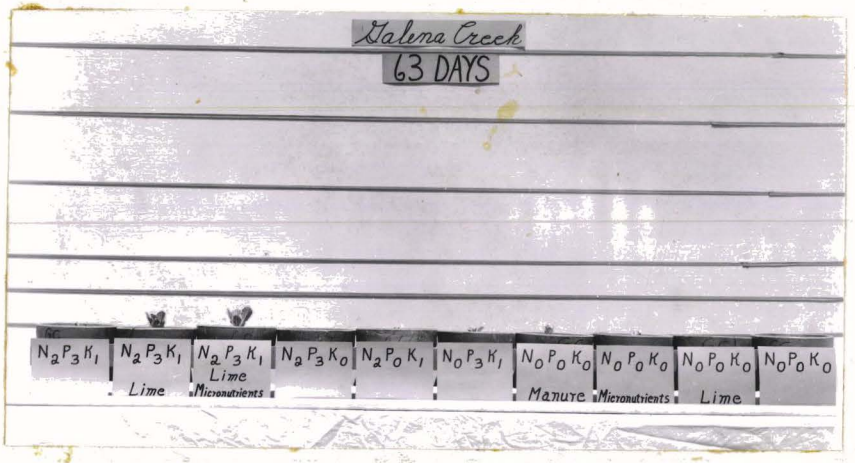


Figure 25 and 26 . Growth of Romaine lettuce or Frontier barley on soil from Smith Valley, a fertile valley soil, compared with soil from Galena Creek when selected treatments were applied.



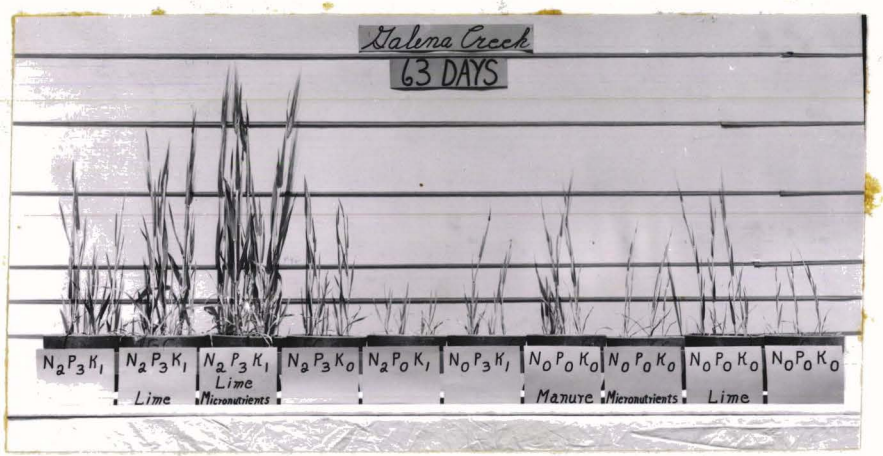


Figure 27 and 28 . Growth of Romaine lettuce and Frontier barley on soil from Galena Creek which had received various macronutrients, micronutrients or other soil amendments.

treatment and 0.32 grams when the micronutrients were omitted. Lettuce plants in pots receiving other treatments made very little growth after they were transplanted into the Galena Creek soil. All lettuce plants still showed some green after 63 days but often most of the leaves on these plants were brown and dry. These tests show that lime, in addition to nitrogen and perhaps phosphates, will be a must if high producing grass stands are to be obtained.

Barley and lettuce plants growing on soils from Dog Valley, Sweetwater Flat, and Abel Creek showed a good response to the application of nitrogen (figs. 29 to 40). On the Border Ruffian soil a good response by barley from application of nitrogen was observed but the addition of lime plus nitrogen was necessary for a good response with lettuce (figs. 41 to 44). Lime appeared to be beneficial at Dog Valley and Border Ruffian but not at Sweetwater or Abel Creek. Phosphates appeared to be beneficial to growth of barley only at Smith Valley and Galena Creek. Phosphates appeared to be beneficial to lettuce growth on soils in Smith Valley, Galena Creek, Dog Valley, Border Ruffian, Abel Creek, and perhaps Sweetwater Flat. The addition of potash did not appear to increase production on any of these soils. Macronutrient appeared to be beneficial only at Galena Creek and Border Ruffian. Application of processed steer manure, at a rate of 5 tons per acre, did not produce the expected results since the response to nitrogen as ammonium nitrate was high on all soils. Available nitrogen may have been very low in this processed steer manure.

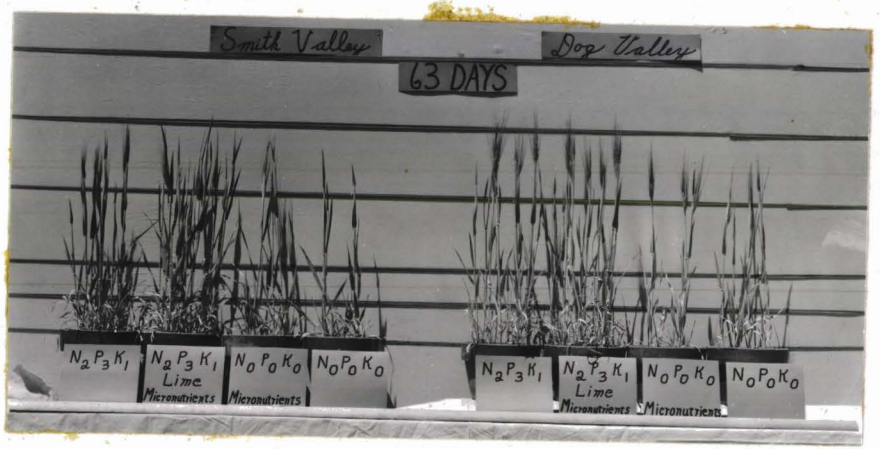
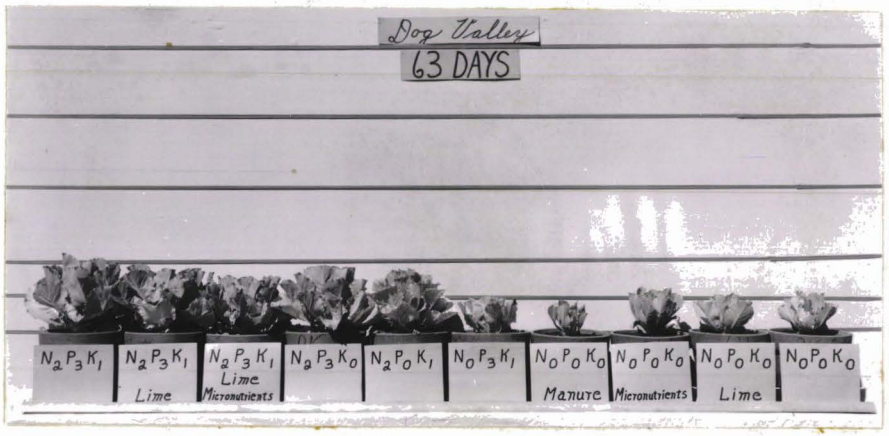


Figure 29 and 30 . Growth of Romaine lettuce or Frontier barley on soil from Smith Valley, a fertile valley soil, compared with soil from Dog Valley when selected treatments were applied.



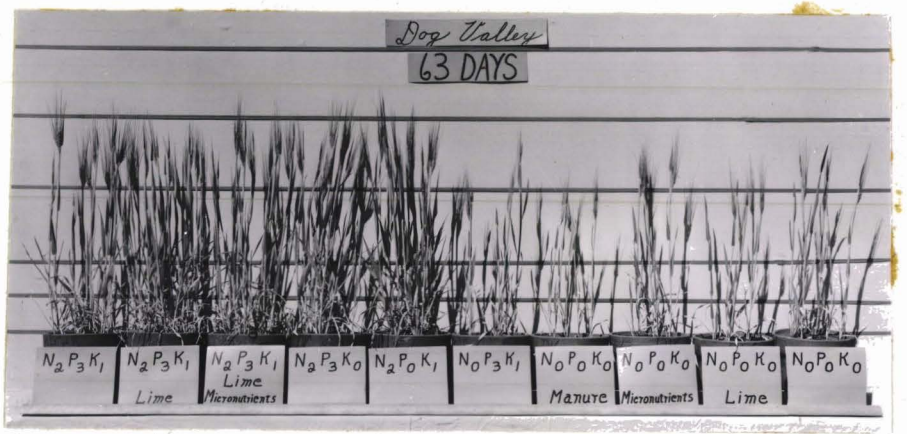
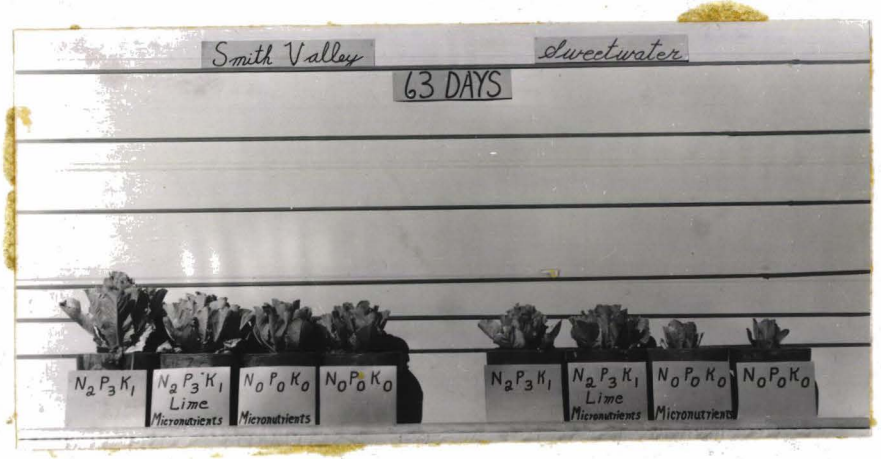


Figure 31 and 32 . Growth of Romaine lettuce and Frontier barley on soil from Dog Valley which had received various macronutrients, micronutrients or other soil amendments.



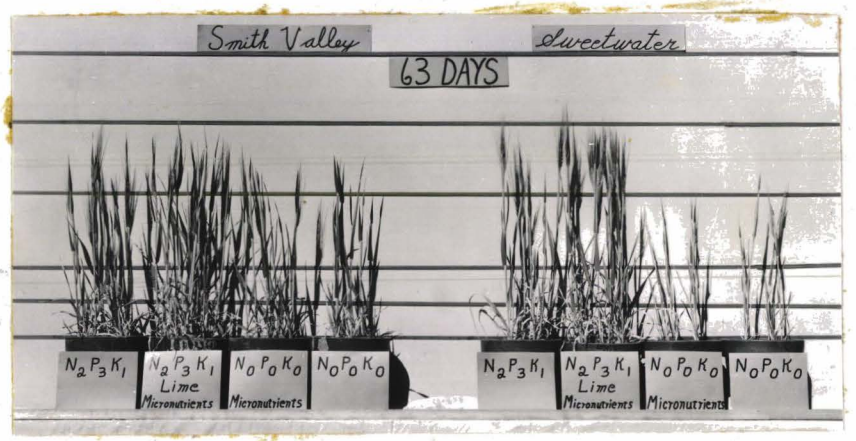


Figure 33 and 34 . Growth of Romaine lettuce or Frontier barley on soil from Smith Valley, a fertile valley soil, compared with soil from Sweetwater Flat when selected treatments were applied.

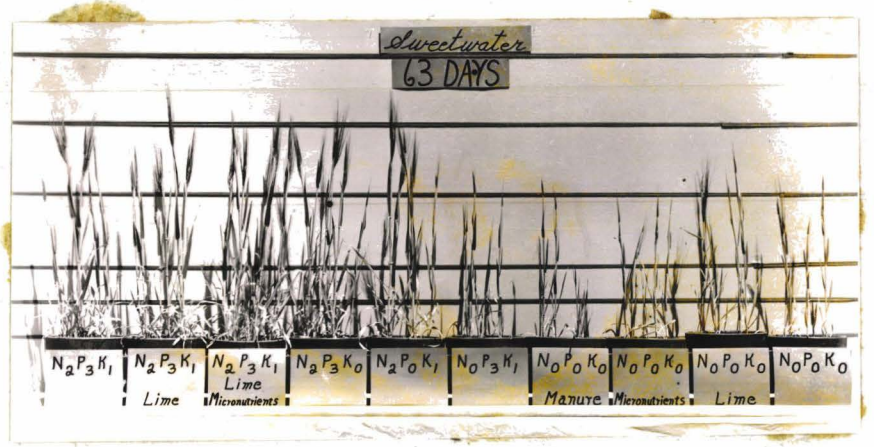


Figure 35 and 36 . Growth of Romaine lettuce and Frontier barley on soil from Sweetwater Flat which had received various macronutrients, micronutrients or other soil amendments.

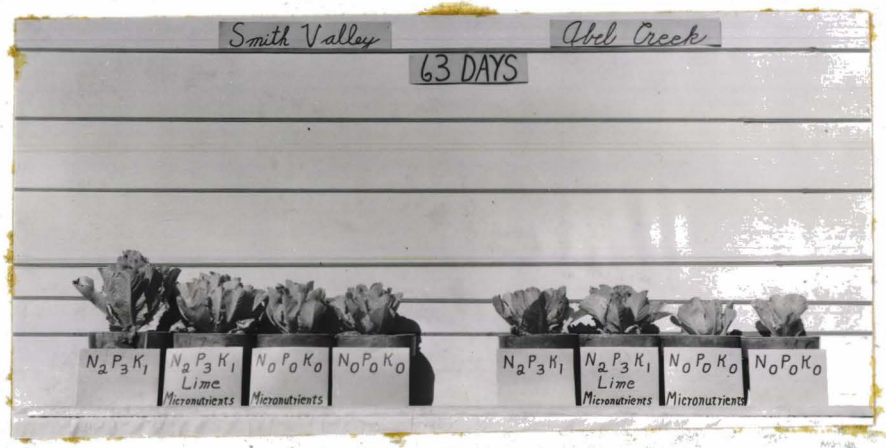
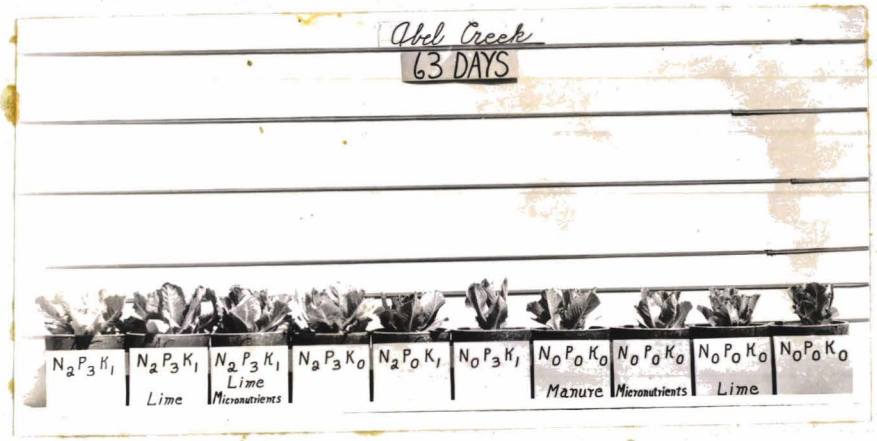


Figure 37 and 38. Growth of Romaine lettuce or Frontier barley on soil from Smith Valley, a fertile valley soil, compared with soil from Abel Creek when selected treatments were applied.



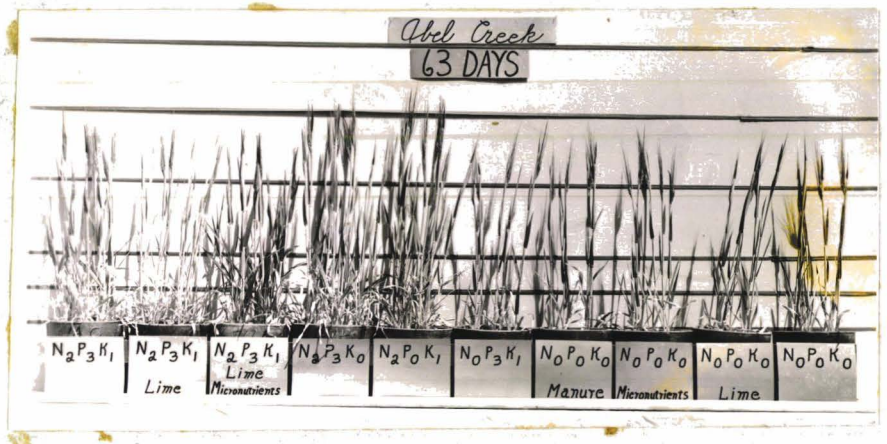
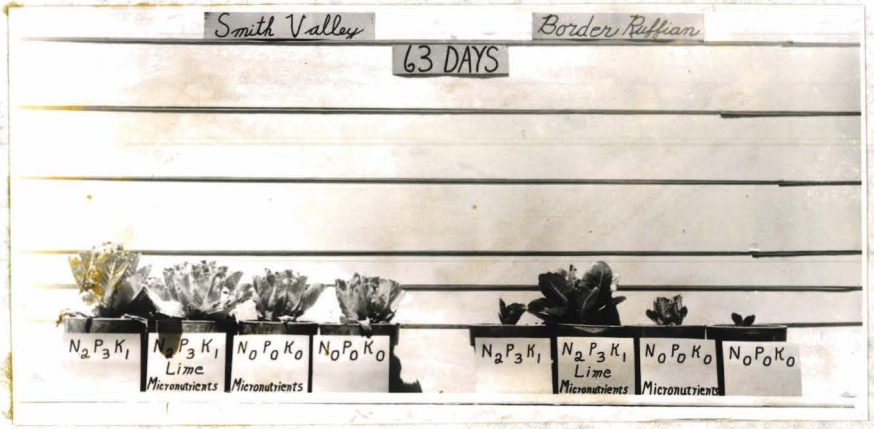


Figure 39 and 40. Growth of Romaine lettuce and Frontier barley on soil from Abel Creek which had received various macronutrients, micronutrients or other soil amendments.



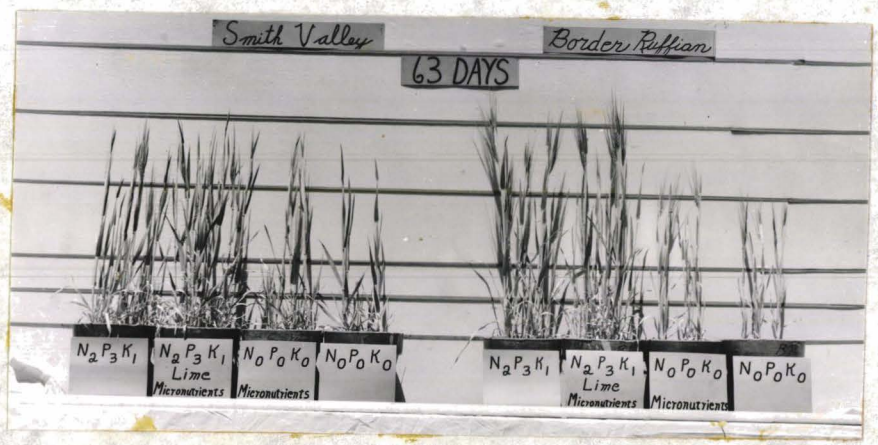
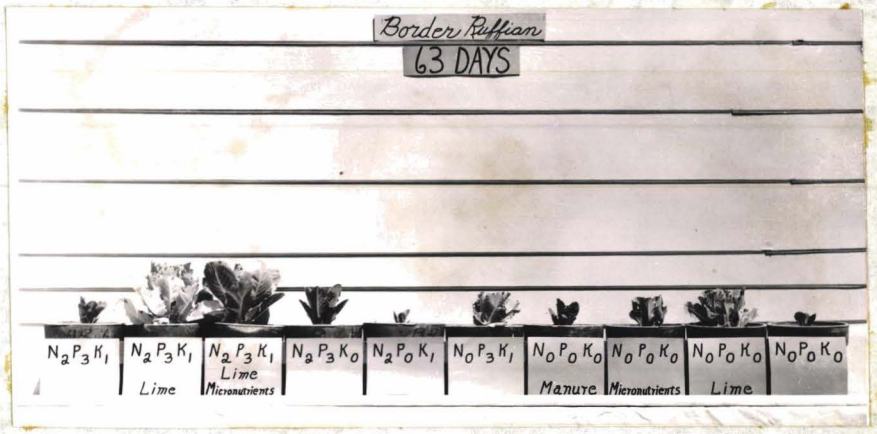


Figure 41 and 42 . Growth of Romaine lettuce or Frontier barley on soil from Smith Valley, a fertile valley soil, compared with soil from Border Ruffian when selected treatments were applied.



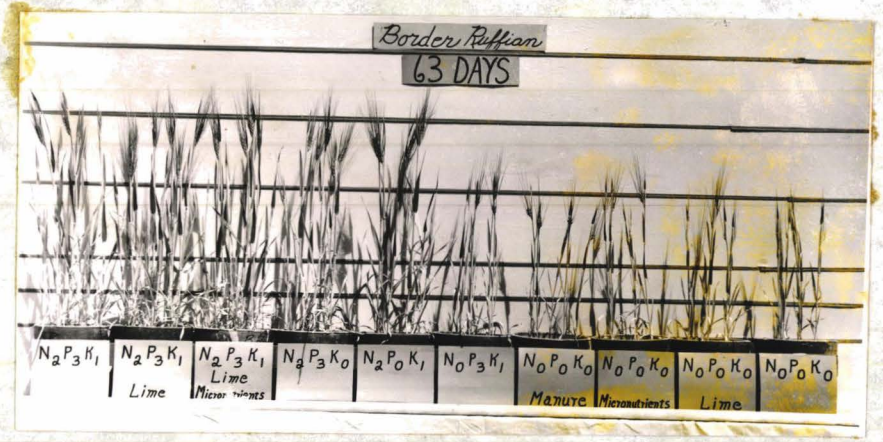


Figure 43 and 44 . Growth of Romaine lettuce and Frontier barley on soil from Border Ruffian which had received various macronutrients, micronutrients or other soil amendments.

The results reported for barley at Abel Creek and Sweetwater Flat are substantiated by field fertility trials on crested wheatgrass at these locations.

III-B. HIGH ELEVATIONS AND HARSH SITES IN UTAH

Most of the intermediate and high elevation ranges are important to the Intermountain region as a watershed and for forage production. Many of these ranges are in a depleted condition. Stock exclosures established on some areas 20 to 40 years ago have shown little or no improvement by natural revegetation.

Generally speaking good grass stands have been obtained by selected species, planted by recommended methods at intermediate and high elevations (fig. 45). Reduction of competing vegetation has been necessary for rapid plant establishment. Drilling with a standard drill, broadcasting and harrowing, or broadcasting on freshly plowed ground has usually given good results, but planting in furrows (deep or semi-deep) have generally given the best results.

At high elevations smooth brome has been the best single species. Good stands have been produced with many other species including tall oatgrass, slender wheatgrass, mountain brome, Kentucky bluegrass, quackgrass, orchardgrass, and timothy. Smooth brome has been superior to most other species because it spreads vegetatively and is long-lived. Seedings of this grass made in 1917 by Dr. A. W. Sampson are still present and largely controlling soil erosion although heavy grazing has been the practice. Short-lived plants such as slender wheatgrass and mountain brome have produced good stands but these stands usually deteriorate and perish with age. Unless these old plants are replaced by volunteer seedlings the soil is left bare (fig. 46).

Figure 45. Good stands of tall oatgrass and smooth brome were obtained from a planting in the fall of 1950 on a critical watershed above Mt. Pleasant, Utah. Plantings in furrows gave the best stands but good stands were produced from broadcasting-harrowing and broadcasting on freshly plowed ground (B56-96).

Figure 46. Good seedling stands were obtained from fall planting in 1948 and 1949 and from spring planting in 1949 and 1950. Short-lived plants such as slender wheatgrass and mountain brome perished leaving bare soil but rhizomatous plants such as the smooth brome on the left have persisted and are slowly spreading. (B56-109).

Much of the topsoil on ranges and watersheds has been lost by erosion. The low fertility in the subsoil remaining may be a factor in plant establishment, production of forage, and erosion control (fig. 47). On the subalpine plots at Bear Creek good seedling stands were obtained but plant establishment was slow and some of the stands obtained did not provide the soil protection required to arrest or retard soil erosion (fig. 48). When the plant density required to arrest active soil erosion was reached, relatively rapid soil build-up occurred by soil deposition from surrounding areas and the accumulation of organic matter (fig. 49).

Some of the fall seedings in the Intermountain region on ranges and watersheds, especially at high elevations have failed. The cause of these failures has often been obscure since species used, seedbed preparation and planting depth have not appeared to be the cause of failure.

An examination of some of these plantings has shown that good stands are frequently growing on rocky ridges (figs. 51 and 52) and south or west facing slopes when only poor stands are growing on the deep fertile soils in swales and valleys. High water marks and other signs observed in the spring of 1956 indicate that water reached in excess of 3 and 5 inches in the early spring on two separate study areas, indicating that flooding may be a factor. Since these areas would normally drain freely this flooding probably occurred during rapid spring snowmelt. Notes on the snow survey on these areas substantiate this theory. Since flooding

Figure 47 . Some of the sub-alpine soils show a marked response to application of fertilizer. Plots on the left were treated with 66 and 42 pounds of nitrogen and P_2O_5 per acre in 1955. (B56-111).

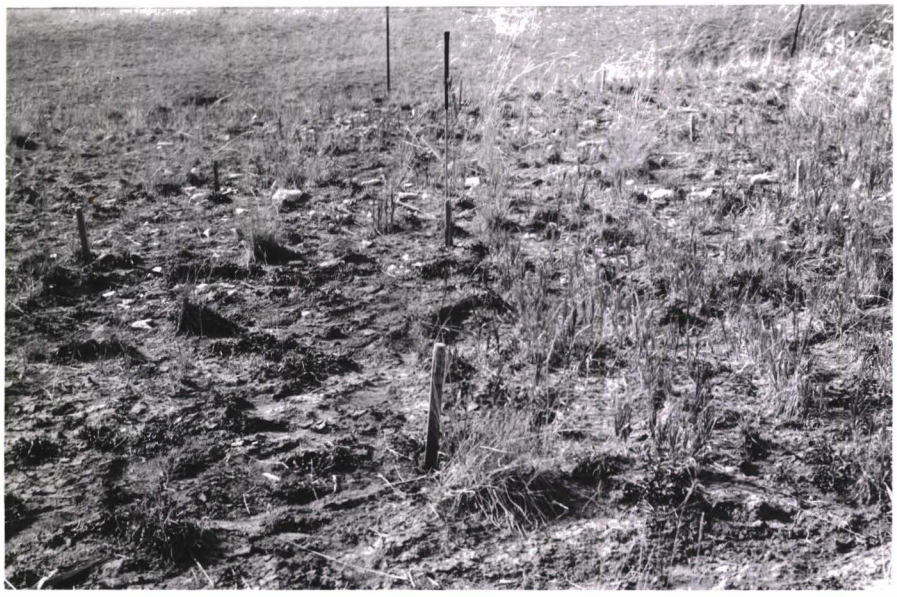


Figure 48 . Good seedling stands were obtained from planting in the spring of 1949 and the fall of 1950 on this severely eroded area. Many short-lived plants of slender wheatgrass and mountain brome have died. Smooth brome has persisted but it has not yet reached the density required to stabilize the soil. (B56-116).

Figure 49. The patch of smooth brome on the left has not only stabilized the soil on this spot but deposition of soil and organic matter has taken place in and around the clump providing additional fertility and increasing the moisture holding capacity of the surrounding soil. (B56-115).

Figure 50. A rhizome planting on a dry south facing shale slope in 1950 produced a fair stand of intermediate wheatgrass in Salt Creek Canyon. (B56-91).

Figures 51 and 52 . Good grass stands have often been obtained on rocky ridges and south and west facing slopes. The bare rocky ridge shown in the upper photo and the crested wheatgrass and smooth brome stand shown in the lower photo adjoin (B56-129 and B56-130).

favors crusting of the soil this may also be an important factor on some of the heavier soils. Seeds of many species begin to germinate at relatively low temperatures or when subjected to moderately high temperatures for short periods of time.

Studies have been conducted on soil and snow temperatures by several institutions or agencies. This work shows that temperatures at or near the soil surface under a snow blanket of 1 or more feet are usually around 30 to 34 degrees Fahrenheit. Seed development and other physiological changes at these temperatures may determine seedling stands produced. Other factors which may influence production of seedling stands are competition for moisture and shade, moisture holding capacity of the soil, soil structure, damage to seed by fungi, bacteria, insects and rodents, and climatic conditions including freezing and frost heaving.

Limited plant establishment has been obtained from seed plantings on some dry, badly eroded, steep slopes. It is believed that selected species will do well once they become established. Exploratory rhizome plantings were made in 1950 and 1951 on selected sites to determine the adaptability of species to these sites and to determine the practicability of this method of planting (fig. 50). Little is known about techniques for planting rhizomes, cuttings, or sod. Additional work on species adapted to these planting procedures and the use of rooting chemicals is needed. While vegetative propagation will have limited application it may be necessary to restory the vegetative cover on many critical areas where seed plantings have been unsuccessful.

W. J. McGinnies established two studies in the subalpine zone in the fall of 1955. One area is located on the ridgetop at the head of Ephraim Canyon where the Ephraim Canyon road joins the Skyline Drive. Elevation at this site is approximately 10,200 feet. Much of the topsoil is gone and the area is covered with shale and limestone rocks (figs. 53 and 54). The native vegetation on the area before planting was a sparse cover of Stipa lettermani, Agropyron trachycaulum, perennial weeds, and a few plants of Ribes.

The other area is located on Philadelphia Flat, a terrace below the ridgetop, at an elevation of approximately 9,950 feet. The native vegetation on this area prior to 1900 was reported to be luxuriant. At this time, soil has been severely depleted and the native vegetation consists primarily of annual weeds and ephemerals such as Viola. Repeated attempts to seed this area have usually failed on the flat bench, but some success has been obtained on the steeper slopes.

The studies established by W. J. McGinnies were identical in design. These studies were put out to compare the effects of furrows, straw mulch, several rates of nitrogen, and a complete fertilizer.

The area located on the rocky ridge in the head of Ephraim Canyon was largely free of snow on March 1 and most of the straw mulch had blown out of the plot area prior to March 1, 1956. Grass seedling counts made on this area on September 7, 1956 are shown in

Figures 53 and 54. Part of this sub-alpine area at the head of Ephraim Canyon was planted in the fall of 1955 but the furrows were planted in the fall of 1956. The plots in the background, planted in 1955, supported a fair to good seedling stand. (B56-141 and B56-143)

table 19. Furrowed plots had a definite advantage over non-furrowed plots. The mulch plot appeared to have some advantage over the plots not mulched but an accumulation of straw, in excess of 2 inches in the furrows, resulted in fewer seedlings in the furrows than on the interspace between rows. Application of fertilizer did not appear to have any advantage over the check plots. A light to moderate stand of barley was growing on this area from seed in the barley straw.

The area on Philadelphia Flat was completely devoid of grass seedlings on May 13, 1956 but a few weed seedlings were just emerging. This area showed definite signs of flood to a depth in excess of 5 inches, although the natural drainage would normally keep water from collecting on this area. High water marks could be seen on all plot stakes and on the straw mulch and a heavy soil crust 1/2 to 1-1/2 inches deep covered the area. By late June some plots were completely dominated by Lupinus alpestris, which had not been killed by plowing. A few grass seedlings came up in late May and June following rainstorms but most of these plants appeared to be native slender wheatgrass. Due to flooding, lupine, soil crusting, and other conditions no response to the treatments were noted and this study was abandoned.

In the late summer and fall of 1956 investigations were initiated in the field to determine the cause of these failures. Plantings were made at three locations on Philadelphia Flat, adjacent to the high ridgetop planting and other selected areas at high elevations.

Table 19 . Number of grass seedlings counted within the alpine harsh site study on September 7, 1956 on plots receiving various soil preparations and rates of fertilizer.

Soil Treatment - Block		Fertilizer Treatment							
	Control	25 N P/A	50 N P/A	100 N P/A	200 N P/A	400 N P/A	Complete Fert.	Total	Average
Control 1	152	58	183	227	49	209	105	983	140.42
(Plowed) 2	44	31	75	24	42	65	40	321	45.85
Plot average	98.0	44.5	129.0	125.5	45.5	137.0	72.5	-	93.14
Straw mulch 1	169	94	139	251	116	165	221	1155	165.00
(Plowed) 2	167	48	94	103	107	150	77	746	106.57
Plot average	168.0	71.0	116.5	177.0	111.5	157.5	149.0	-	135.79
Furrows 1 Ridge	117	53	91	163	120	137	116	797	113.86
Straw mulch 1 Furrow	107	63	67	99	74	73	102	585	83.57
(Plowed) 2 Ridge	238	102	93	105	192	181	93	1004	143.43
2 Furrow	86	60	71	73	108	214	71	683	97.57
Ave. on Ridges	177.5	77.5	92.0	134.0	156.0	159.0	104.5	-	128.64
Ave. on Furrows	96.5	61.5	69.0	86.0	91.0	143.5	86.5	-	90.57
Plot Average	274.0	139.0	161.0	220.0	247.0	302.5	191.0	-	219.21
Furrows 1 Ridge	110	150	55	149	150	158	145	917	131.00
(Plowed) 1 Furrow	214	130	57	182	163	138	162	1046	149.43
2 Ridge	109	81	107	129	65	77	158	726	103.71
2 Furrow	175	109	122	208	154	157	176	1101	157.29
Ave. on Ridges	109.5	115.5	81.0	139.0	107.5	117.5	151.5	-	117.36
Ave. on Furrows	194.5	119.5	89.5	195.0	158.5	147.5	169.0	-	153.36
Plot Average	304.5	235.0	170.5	334.0	266.0	265.0	320.5	-	270.79
Grand Average	211.12	122.37	144.25	214.12	167.50	215.50	183.25	-	179.73

A. On Philadelphia Flat, a study was made to determine the relative effects of furrows compared to no furrows, sawdust mulch compared to no mulch, and nitrogen fertilizer compared to no fertilizer. A total of eight different treatments were used. A plot diagram is shown in figure 55. Each treatment was replicated six times. Furrows 4 inches deep were spaced 2 feet apart in the furrowed plots (fig. 56). All plots were planted with Manchar smooth brome at a depth of 3/4-inch and at a rate of 10 pounds per acre. A Planet Junior was used for planting and rows were made 1 foot apart. In the furrowed plots one row was planted on the interspace between the furrows. Sawdust was hand broadcast at a rate of 2 cubic feet per 100 square feet of area. Ammonium nitrate was broadcast over the area at a rate of 100 pounds per acre.

B. Row plantings were made on six areas with various slopes and soil types so that a comparison of seedling stands on these areas in the spring of 1957 could be made. Furrows 20 feet long and 4 inches deep were made with a hand cultivator. Seed of smooth brome was planted at a depth of 3/4 inches in the bottom of each furrow. Seeding rate with the Planet Junior was set for 10 pounds per acre when rows were spaced 1 foot apart. The locations of the study areas are listed below.

1. Philadelphia Flat. Abandoned study established by W. J. McGinnies. Sixteen furrows (8 on mulched plots and 8 on bare plots) were established on the west end of abandoned study which was relatively free of lupine (fig. 57).

sawdust	sawdust nitrogen	nitrogen	(check)	sawdust nitrogen	nitrogen	sawdust	(check)
furrows	furrows sawdust	furrows sawdust nitrogen	furrows nitrogen	furrows	furrows nitrogen	furrows sawdust nitrogen	furrows sawdust
sawdust	(check)	sawdust nitrogen	nitrogen	(check)	sawdust	nitrogen	sawdust nitrogen
sawdust	sawdust nitrogen	nitrogen	(check)	furrows sawdust nitrogen	furrows nitrogen	furrows	furrows sawdust
furrows sawdust nitrogen	furrows nitrogen	furrows	furrows sawdust	sawdust	sawdust nitrogen	nitrogen	(check)
furrows	furrows sawdust	furrows sawdust nitrogen	furrows nitrogen	furrows	furrows nitrogen	furrows sawdust nitrogen	furrows sawdust
						10 ft.	10 ft.

10 ft.

10 ft.

Furrows- 5 per plot 2 feet apart and 4 inches deep.

Sawdust- 2 cubic feet per 10 square feet.

Nitrogen at 100 pounds of N per acre.

Seeded to Manchar smooth brome at 10 pounds per acre.

(10 rows in each plot)

Figure 55 . Plot diagram for a methods of planting study on a harsh site, Philadelphia Flat, Ephraim Canyon, Utah.

Figure 56 . Several attempts to seed this area have failed. The relative effects of furrows, sawdust mulch and nitrogen fertilizer on seedling establishment will be determined. (B56-138)

Figure 57 . Row plantings were made on this abandoned study in the fall of 1956 to compare seed germination and establishment on this area with other areas with different soils or exposures. (B56-134)

2. Philadelphia Flat. Located on a 15 percent slope, 300 yards south of number (1) above. Four furrows were established with the contour of the slope.

3. Head of Ephraim Canyon. This area adjoins the 1955 planting which produced fair to good seedling stands in the spring of 1956. Eight furrows were made south of the 1955 planting (figs. 53 and 54).

4. Bear Creek. Established on lower portion of a livestock exclosure near road and east of old log and block enclosure. Good seedling stands were produced on this or adjacent areas from fall plantings in 1948 and 1949 and spring plantings in 1949 and 1950.

5. Manti Ridge. Located within a large administrative Forest Service planting. Three furrows 100 feet long extend from bottom of swale onto slope of approximately 8 percent and on rocky ridge. Good stands were produced on the rocky ridge but poor stands were produced on the deep soil in the swale from the planting in the fall of 1949.

6. Buck Ridge, near old Sampson plots. Six rows were established. Rows are in pairs with two near rocky ridgetop, two on rocky ridge face, and two on a level terrace.

C. Seeds of Manchar smooth brome, with a germination of 95.4 percent, were placed in small cloth bags with 100 seeds per bag. On November 2, 1956 bags were placed under 1/2-inch of soil and the

original snow cover of about 14 inches was replaced. Seeds were not moistened prior to planting. The soil under the snow was wet and free of frost. Sacks containing seeds were placed at three locations with five separate planting sites at each location. Sacks will be removed from one planting site at each location beginning with active spring snowmelt and at intervals until normal spring emergence takes place at this elevation. Seeds will be examined for stage of development and visible damage before germination tests are made in the laboratory.

D. It is believed that under certain conditions free water from melting snow may stand on the soil at depths up to 3 to 5 inches deep prior to complete melting of the snow. "Free water traps" were made and set out near the locations shown in (B) above, to determine if free water under the snowpack exceeds 1, 2, or 3 inches in the spring of 1957 (figs. 58 and 59). "Free water traps" were made by placing a small can, bottom side up, over the top of an open 1/2 quart beverage can, as a loose lid. These cans were fastened together with wire so that bottom of the inverted can was at least 1/2 inch above the top of the beverage can. The larger diameter of the top can gave a minimum of 1/4 inch of space between the sides of the top can and the beverage can. Cans were then buried in the soil so that the lip of the beverage can was 1, 2, or 3 inches above the soil surface. These traps can only be filled by flowing water.

Figure 58 . "Free water traps" were set out to determine if free water accumulates under the snow during rapid spring melting. (B56-136).

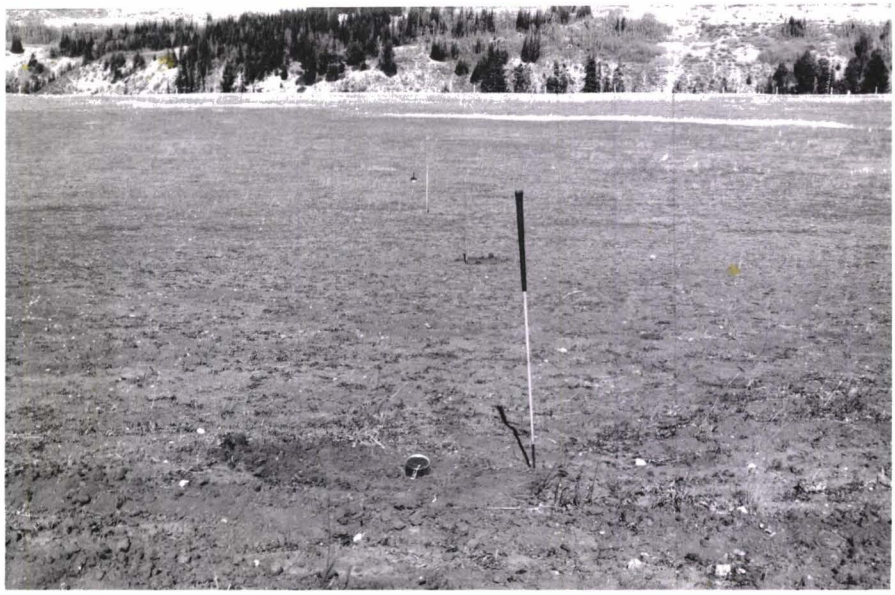


Figure 59 . "Free water traps" were buried with the lip of the beverage can 1, 2 or 3 inches above the soil surface. (B56-144).

When the area described in "C", above, is sampled soil moisture at the 0 - 3 inch soil depth will be determined and the presence of free water will be noted.

E. Additional plantings of seed in small cloth bags were made under 1/2 inch of soil and the existing snow cover on November 30, 1956 and January 4, 1957. These plantings were made at headquarters station, elevation 8,850 feet. Prior to planting on November 30, 100 seeds of Manchar smooth brome were placed in cloth bags, about 4x5 inches in size. Average germination of this smooth brome seed was 95.4 percent. Part of this seed was placed in a germinator for 8 hours at 30°C. and 20°C. for 24 hours. At the end of this period the tip of the radicle was visible on 23 percent of these seeds. The remainder of the seed was moistened and subjected to a temperature of 20°C. for 2 hours, just prior to planting. Seed was planted at five separate locations. On this date the average snow depth was 14 inches. The soil under the snow was frozen to a depth of approximately 1 inch. The frozen soil was chopped out and sacks were placed on the native soil. The sacks were then covered with 1/2-inch of dry soil and the original snow cover was shoveled back into the hole. All sacks placed in each hole were tied onto a single strong cord which was fastened to a nearby pole so that the seed could be easily located. Sacks containing seed of Manchar smooth brome and tall meadow oatgrass were planted in five separate locations on January 4, 1957. Seeds were

moistened and subjected to a temperature of 20°C. for 2 hours prior to planting. On this date the soil was frozen to a depth of 1/4 to 1/2 inch. Snow depth was 31 inches. Planting procedures described above were used.

Sacks from one location are to be removed on the first week of each month beginning in January. Seeds will be examined for germination, fungi, or other damage prior to germination in the laboratory.

III-C. RESURVEY OF THE MILKRANCH POINT PELLET PROJECT

This study is located in southeastern Utah on the Monticello District of the LaSal Division of the Manti-LaSal National Forest. Field work was conducted by A. C. Hull, Jr. and A. T. Bleak during July 1955.

Plantings were made to compare pelleted seed with unpelleted seed, as well as measure the effect of several ground preparations and seed covering methods on establishment of mature stands. This study showed that seeds in compressed pellets did not have any advantage over unpelleted seed. In the ponderosa pine, mountain brush, and juniper-pinyon types successful stands were produced from pelleted seed only where competing vegetation was reduced. In the aspen type, fair stands were produced under the aspen canopy by both pelleted and unpelleted seed. Factors which limited plant numbers and forage yields from planted species were reduced seed germination due to pelleting, unfavorable conditions for seed germination or plant establishment and competition by native vegetation. A paper, "Seeding Pelleted and Unpelleted Seed in Four Range Types" has been submitted to the Journal of Range Management and this study has been closed.